# Popular Astronomy.

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## MISCELLANY.

R. W. McFARLAND.

FOR POPULAR ASTRONOMY.

About a year ago there was published in England a new treatise on Chronology. The burden of the work was an attempt to show that in dating the number which stands for the year denotes the completed, not the current year. The treatise signally failed to establish its point of contention. It is easy to show that among the civilized nations of Europe and Western Asia, it has always been the custom to denote not only the year, but also the month and the day as current, not completed. A brief review of the book was printed in this Journal a few months since.

One point was omitted in that notice, the intention being to call it up later, as I do now, viz. the effect of such proposed change on the Julian period, and on the rule for finding the Julian year when certain cycles are given,—the Golden number, the Roman Indiction, and the Solar cycle. The theory of that period assumes that the number denotes the *current* year, and that 4713 complete years of the period had passed at the beginning of the year 1. A. D. The Lunar cycle, or Golden number has now been in use for more than twenty three centuries; the Roman Indiction was used before the Council of Nice in A. D. 325, and the Solar cycle, for probably fifteen centuries. Students of astronomy know that the cycle of the Indiction is fifteen years; the Golden number, nineteen; and the Solar cycle, twenty eight. The product of these three numbers is the cycle of the Julian period, 7980. The invention of this period is attributed to Joseph Scaliger, the celebrated scholar, in the latter part of the sixteenth century. The cycle twenty eight is only the product of seven, the number of the days in a week, by four, the number from one leap year to the next. In this cycle, the days of the month run through all their possible changes so far as the days of the week are concerned, in the old style way of reckoning. The Gregorian calendar by omitting certain centesimal years as leap years, breaks the regularity of these changes. To illustrate: in general, any day of

any month, as the fourth of March must fall on Sunday at least once in twenty eight years; it may occur three or four times. So the twenty ninth of February occurs on Sunday once in twenty eight years, except when that period embraces one of the centesimal years which is not a leap year, as 1700, 1800, 1900,—then it is forty years from the time the twenty ninth of February falls on Sunday to the next time it occurs on the same day.

Sixty or seventy years ago, an item went the rounds of the newspapers of the time, to the effect that the framers of the constitution of the United States selected the fourth of March for inauguration of the Presidents, because the day would not fall on Sunday for 300 years. Even if we should consider the statement as a tribute to the piety of those men, it is at the expense of their intelligence.

The method of finding the Golden number, Indiction, and Solar cycle for any year is given in works in Astronomy, and need not be repeated here. The reverse process of finding the year when the three cycles are known is not so simple a problem as one might suppose. For this reverse process Sir John Herschel gives Hutton's rule without any explanation. Hutton himself explains it only in part. The rule is as follows: Multiply the Solar cycle by 4845, the Golden number by 4200, the Roman Indiction by 6916, add the products, and divide the sum by 7980, the remainder is the year of the Julian period. From this Julian period subtract 4713, and this new remainder is the year of the Christian era.

It is probable that a good many readers of this Journal would find it a little troublesome to prove the truth of Herschel's rule.

It is not usually stated in works on Astronomy that the length of the month and of the year as given, denote only the *average* length of those periods. The usual statements make no allusion to these variations. But the fact is that the revolutions of the moon in the winter require nearly half a day more than those in midsummer, and no two months are of the same length, even in the lapse of many centuries. To give the length of the month, then, within the hundredth of a second is entirely unwarranted and misleading.

The year also varies by nearly half an hour between the successive returns of the Sun to the vernal equinox. This interval of course is the true year. If any person will take the trouble to find the time when the center of the Sun is on the equator in March, for ten or a dozen successive years, he will find the facts as above stated,—the years will vary ten or fifteen minutes below

or above the average. Of course astronomers understand the reason of these variations. The more wonderful then is the accuracy with which the ancient Egyptians determined the length of the year, more than a thousand years before the beginning of the Christian Era.

In the Nautical almanac it is customary to give the day of the Julian Period which the first day of January shows; as this, "January 1st 1900, is the 2, 415, 021st day." The beginning of the period was determined mathematically by finding the year in which the Golden number, the Solar cycle, and the Roman Indiction were each unity, using 753 B. C. as the year of Rome, disregarding other dates for that event.

To find the day of the week on which a given day of a given month may fall, is a problem often met with. Rules for different centuries have been formed, and tables have been constructed for the solution. There is a simple but comprehensive method applicable to all centuries. The year consisting of fifty two weeks and one day, it follows then in general, the year begins and ends on the same day of the week, except in leap years, it ends one day later. This year, 1905, began on Sunday; it will end on Sunday, New Year's day in 1906 will fall on Monday. The year following a leap year will begin two days later. What is true for the first day of January is true for any other day of the year.

If then we take the number of years between two dates, and add the number of years in which there has been a twenty-ninth of February, we shall have the number of days which a date has been thrown forward in the week. For example, in 1905 the first of November fell on Wednesday: on what day of the week will November first 1955 fall? The interval is fifty years, and there are twelve leap years,—sixty two days in all. But this is six days more than eight weeks: and counting six days forward from Wednesday, we reach Tuesday, the day of the week for November 1, 1955.

For time past the day is set back, not forward, but is found in the same way. For example, what day of the week was November 1, 1855? As before, the displacement is sixty two days, and counting back six days from Wednesday, we reach Thursday, which was November 1, 1855. The change from Old to New Style was made in England on September 14, 1752, i. e., the fourteenth was the first day of New Style. Required the day of the week. The interval is 153 years, and there have been thirty six leap years, 189 days, or twenty seven full weeks. And as the fourteenth this year fell on Thursday, it fell on Thursday in 1752. The

earliest printed statement of this method which I have seen, is that in Newcomb & Holden's Astronomy, printed about twenty five years ago. But up to the present I have never spoken with any one who was acquainted with the process.

It is a well known fact that the old Roman writers differed in their estimates of the time when Rome was founded,—differed by six or seven years.

At the time of writing the critique on the new work on Chronology spoken of above, I had at hand a copy of the International Bible Society's edition of the Revised version of the Scriptures. There were essays on various topics, two elaborate ones being on Biblical Chronology. These differed from each other in several important particulars, and differed also from all other systems which have been examined by myself. And within the last few days I have seen some dates professedly taken from the third volume of Petrie's History of Egypt, a new work. The author stands at the head of the Egyptologists of the day, and his dates differ from those of all other writers falling within my notice. It is thus evident that it is impossible to fix those old dates with any approach to certainty.

Oxford Ohio.

## CONSTRUCTION OF LARGE TELESCOPE LENSES.*

Dr. C. FAULHABER.

The three principal instruments for the study of the heavenly bodies are the telescope, the spectroscope, and the photographic camera; and since the two latter are made useful only as they are attached to the former, it is the telescope which we must still regard as the key to unlock the doors of the universe. Readers have all doubtless seen a large telescope, and many have had an opportunity of looking through one, for most observatories reserve certain hours for the public. Accordingly a description of the instrument as a whole may be omitted, and we will merely recall that, notwithstanding it is so long and heavy, complicated mechanical and electrical means are provided for pointing and accurately guiding the telescope, so that it follows automatically the motion of any chosen celestial object. But no less hard than the difficulty of providing these mechanical adjuncts is the optical

* Translated, by permission, from Prometheus, Berlin, Vol. XV, Nos. 34-35, 1900. From *Smithsonian Report*, 1904.

problem of providing the great double lens called the objective at the upper end of the tube. The objective is the fundamental part of the telescope, on whose excellence the value of the whole instrument depends, and not only its quality but its size also is of the highest importance to make possible the observation of objects otherwise forever invisible. Hence it is that telescopes are designated, not by the maximum magnification which they can produce, nor by their length, but rather by the diameter of their objectives. Thus one speaks of the 40-inch of the Yerkes Observatory, the 36-inch of the Lick Observatory, and the 32-inch Potsdam refractor.

In order to study the construction of a great telescope objective, the attention of the reader is now invited to a great optical glass works, of which there are but three principal ones in the world, namely, those of Schott & Genossen, in Jena; Mantois, in Paris; and Chance Bros. & Co., in Birmingham.

To begin the process of construction a crucible of fire-proof clay, which already has been warmed gradually for several days, is placed within a melting oven of peculiar construction. This oven is then closed and slowly heated to white heat, while at the same time the materials to compose the glass are admitted to the melting pot through a peehole about as large as a man's head in the wall of the oven.

The material varies with the kind of glass to be made. Until the beginning of the year 1880 only two kinds of optical glass were in use, of which one—the so-called crown glass—was composed of quartz sand, potash, soda, and calcspar, and the other —the so-called flint glass—was composed of quartz sand, potash, and lead oxide. There are now more than 100 varieties of optical glass produced by the intermixture of other materials, such as phosphorus, boric acid, magnesium, zinc, barium, antimony, which are distinguished by different properties of dispersion and refraction. The choice of the proper glass for the two lenses depends on the purpose which the telescope is to serve, and particularly whether it is to be employed for visual or photographic observations.

About thirty hours is consumed in the introduction of the materials. If there be no mishap—for sometimes at the temperature of 1,600° to 1,800° the melting pot cracks or even the stones of the oven burst—the impurities are then skimmed off from the surface, and for about fifteen hours the mixture is stirred by means of a hook-shaped, white-hot clay cylinder.

When the ingredients of the glass are melted they have a ten-

dency to separate in layers according to their specific gravities, and thus to destroy the homogeneity required for optical purposes. This difficulty is chiefly overcome by the continuous stirring of the melted mixture. By repeated tests the moment is at length found when the charge assumes the proper color and degree of fluidity. When this moment arrives the farther side of the oven is opened and a two-wheeled truck with long handles is backed up to the opening. Two projecting pieces of the truck reach out under a ring which is made for this purpose on the clay melting pot, and the latter is carefully lifted from the floor of the oven. On account of the overflow of melted glass, which often cements the pot to the bottom of the oven, this is an operation involving a great risk that the fragile white-hot clay melting pot may break, owing to the shaking required to free it from the oven.

The melting pot is next moved over to a great circular iron mold, and is then set down upon the floor, in order to reinforce the pot with an iron band. On opposite sides of the iron band are steel pins fitting on hooks attached to the truck. By means of this arrangement the pot is lifted above the mold and its contents poured therein. Contrary to what might perhaps be expected, this process is accomplished with little noise beyond a slight crackling and rustling sound. This is the culminating point in the whole process of glass making, and gives rise not only among unaccustomed onlookers, but also among the skilled workers themselves to mingled feelings of great anxiety and exalted admiration.

The mold with its fiery contents is then covered with an iron plate and pushed over to the cooling oven, which has in the meanwhile been carefully heated and opened ready to receive the charge. Here the mold is lifted by a tackle and thrust into the cooling oven, where, after the walls have been sealed up as tightly as possible, it remains from four to six weeks undisturbed. Very gradual lowering of the temperature is required, else the cooled mass might burst with the slightest touch, or at least show prejudicial strains in the interior.

When at length the oven is opened the mold is found to contain a solid, feebly lustrous, milk-white plate, which is easily removed from its iron bed.

There now begins a week-long process of grinding and polishing of the glass plate preparatory to a preliminary examination as to its freedom from strie, bubbles, and conditions of interior strain. Experience shows that in general only a part of such a plate is of optical value. This part is cut out by means of a

glass saw and again heated till soft in a crucible, which corresponds approximately with the final form of the objective. After this comes a second gradual cooling during a period of several weeks and another rough polishing and testing of the quality of the resulting plate of glass.

In favorable cases the product is now ready for removal to the optical shop, but commonly there are ten or more unfavorable trials before securing a successful result in the manufacture of a disk of glass for a lens of one meter diameter. Since, as we know, there are two such disks of equal size required for a telescope objective, weeks and months of further work are required for the production of the second. The process is in all respects the same, except that somewhat different materials are employed for the mixture, corresponding to the differences in optical properties desired. In outward appearance crown and flint lenses do not differ much, but one is somewhat heavier than the other.

The description just given relates to the most modern methods of glass making as they would now be pursued at Jena in the manufacture of glass disks for a telescope of 1.25 meters aperture. In the old processes it was customary to melt a charge about three times as large as required, and after this had reached the proper color and consistency, to allow the melting oven to cool slowly and thus to take the place of the special cooling oven. On opening the oven the glass block would be found broken in several pieces, and if there was none among these which would answer the purpose the process would then be repeated. When a rough block of suitable size and quality was obtained it was put in a crucible of about the proper lens form. The whole was then again melted and cooled and then polished for testing. As an example of the cost in time spent in this procedure, it will be recalled that the Paris glass works required four years for the production of the two lenses of the 36-inch Lick objective. The melting was done twenty times, and each time a month was spent in the cooling. On the other hand, the Jena glass works employing the improved processes, prepared both disks of the slightly smaller Potsdam 80-centimeter objective in a few months.

It may be of interest to rehearse briefly the story of the rapid development of the industry of optical glass making in Germany, principally during the last ten years.

The pioneer in the production of glass for astronomical purposes, according to purely scientific methods, was the renowned Joseph von Fraunhofer, of Munich (1787-1826). But it is only twenty years since Professor Abbe and the glass manufacturer,

Doctor Schott, of Jena, took up the work where Fraunhofer laid it down, and succeeded in replacing the old flint and crown glases by new varieties of glass, by means of which the chromatic differences of spherical aberration are nearly eliminated. The production of the new glasses on a commercial scale began in the autumn of 1884. In order to support the very costly preliminary experiments, the Prussian Government made considerable grants of money in consideration of the national value of the work. This governmental support was required but two years, for the undertaking progressed favorably and the productions found recognition almost immediately in the whole optical world, so that soon not only German, but foreign optical establishments, placed most of their orders for material in Jena. Not only are the common crown and flint glasses made here, but also a great number of improved crown and flint glasses, containing boric and phosphoric acids, to diminish the secondary spectrum on the one hand, and on the other containing metallic oxides, by means of which the dispersion and refraction may be increased or diminished. An extensive exhibition of these products was witnessed by the visitors who attended the Berlin Gewerbe-Ausstellung in 1896. There were shown disks for the construction of telescopic objectives of 110 and 125 centimeters diameter, and these were the largest pieces of optical glass which had then been made. Not only is optical glass produced for all kinds of instruments of precision, but also there is made at Jena glass tubing for physical, chemical, manufacturing, and medicinal purposes, and all sorts of chemical glassware, such as flasks, beakers, and retorts, besides cylinders for gas and petroleum lighting. There are now employed in this industry about 650 persons, and the value of the yearly output reaches 3,000,000 marks.

We are now prepared to trace to the further stages in the preparation of a great objective, and the attention of the reader is invited to the optical workshop. Here the glass disks are first ground and polished on both sides preparatory to a thorough testing. For this purpose there is a machine with a vertical spindle carrying an iron plate.

Upon this plate the glass disks are in their turn cemented with pitch, and above is a second iron plate, the grinder, provided with a spindle in the center. By means of this spindle the grinding plate is shoved hither and thither over the glass disk by machinery. The grinding material is emery powder and water. After the rough grinding is done the rough polishing on the same machine follows similarly, excepting that the grinding tool is

replaced by a cloth-covered polishing tool, covered with rouge instead of emery.

After this preliminary work, a careful investigation of the disks is made in the laboratory by the aid of the microscope and polarization apparatus. If the objective is good it must appear bright in the polariscope, with the exception of being marked by a regular dark cross. If an irregular cross is seen or, in certain conditions, brightly colored figures of various shapes, the disk must be returned to the glassworks to be remelted and cooled.

In case of a satisfactory outcome of these tests small pieces are cut off and prisms are prepared from them, whose refractive indices are determined by means of the spectrometer. Upon these measurements are based the accurate computation of the objective—that is to say, the determination of the four radii of curvature and the thickness—a tedious piece of work which requires repeated independent checking.

After this begins the real preparation of the objective lenses, one of which is to be ground concave, the other convex, on the same machine which was used in the rough grinding. This present procedure is similar to that already described, except that grinding tools opposite in curvature to the lenses and made of iron, brass, or glass are fed with finer and finer emery powder as the work approaches its finish.

Since everything depends on the proper guiding of the grinding tool to obtain the regular spherical surfaces, the operating of the machine demands great experience and care, and the work requires frequent testing by the application of the spherometer. When finally the right curvature is reached, after many days of work, repeated and accurate testing of the lens is made by the Toppler "Schlieren-methode" for small errors, nonhomogeneity, and other faults.

The fine-ground lens is now put upon a lathe and centered by means of a fine adjusting crane. This centering consists of shifting the lens about upon the spindle of the lathe until exact coincidence is reached between the optic axis (common axis of curvature of the two surfaces) and the mechanical axis of the spindle. Recognition of this condition depends on observing the reflections from the two glass surfaces, and accurate centering is reached when these reflections do not move with the rotation of the spindle. When the right adjustment is made the edge of the disk is turned off true by means of a grinding band fed with emery and water, and by this means the lens is reduced to the proper diameter.

After the centering follows the fine polishing on a special polishing machine. The process is much the same as that of rough polishing, excepting that instead of a cloth-covered tool there is provided for each face a series of great pitch-covered plates. Frequent trials of the surfaces are made by means of so-called "test glasses." These are small glass plates ground and polished accurately to fit the desired curve; that is to say, convex for a concave surface, and vice versa. Their employment in testing depends on the following principle: If two closely fitting polished surfaces are laid one upon the other there is retained between them a thin film of air which exhibits the so-called "Newton's colors," seen in soap bubbles and similar thin transparent structures. The color is the same over the whole surface only when the thickness of the inclosed film is everywhere uniform, which only occurs when the lens has the same curvature as the test glass. At the beginning of the polishing the Newton's colors appear as rings of more or less width. By the proper use of polishing tools of different sizes, and by suitable regulation of the stroke and velocity of the machine, the condition is finally reached when a uniform color supersedes the rings, no matter where the test glass is laid upon the lens. By such methods of measurement in terms of the wave length of light, deviations of thickness of only one ten-thousandth millimeter (one two-hundred-and-fifty-thousandth inch) can be accurately detected, a magnitude scarcely appreciable to the lay mind. It is obvious that the fine polishing in such conditions is an exceptionally difficult task, the more so that care must always be exercised to avoid all blemishes on the surfaces, such as scratches and the like, and only the most competent and experienced workers can succeed with it. A conception of the difficulties to be overcome may be found when it is said that the fine polishing of a single lens surface takes several months.

When both lenses have passed through the processes of fine grinding and polishing they are inserted in brass or iron mountings which have meanwhile been prepared for them and in which they lie separated by a small free space. Cementing together with Canada balsam or turpentine, as generally practiced with small lenses, and formerly with large ones also, has more recently discontinued on account of the difficulty of separating large cemented lenses for subsequent cleaning.

After the lenses have been placed in their cell there remains only the final testing in the telescope tube itself. I shall not describe the complicated centering apparatus employed in this test. The

errors of an objective and their causes are numerous, and their discovery and correction demand great experience and skill.

In conclusion, we may inquire where the telescopes of largest objectives are located, and by whom they were made. In the first place, there is the objective made for the Paris Exposition of 1900, but not among the telescopes in present use. It is 1.24 meters in diameter, and the glass alone weighs 580 kilograms, of which the convex lens weighs 360 and the concave lens 220 kilograms. The cost of the two lenses was 75,000 francs. These disks were poured by Mantois and ground by Martins, both of Paris. Up to the present time the objective has not been usefully employed. The second and third places, as regards size alone, are taken by the objectives of the Yerkes Observatory, near Chicago (1897), and that of the Lick Observatory, at Mount Hamilton, Cal., with diameters, respectively, of 105 and 91 centimeters. Both were poured at the Paris glass works and figured by Alvan Clark in Cambridgeport, Mass.

They are both satisfactory, though not prepared entirely on the basis of computation, but rather by repeated trials, and brought to their completion by the so-called method of local correction. After them in size comes the great refractor of the Potsdam Observatory, prepared solely for celestial photography and having a diameter of 80 centimeters. This objective was poured in Jena and figured at the optical works of C. A. Steinheil Söhne, in Munich, in 1899. It is recognized to be of the highest order of merit and is a strong testimony to the ability of German manufacturers in this line. The Potsdam refractor has, in addition to the 80-centimeter photographic lens, a second visual lens of 50 centimeters diameter, and being thus a double refractor is perhaps the largest astronomical instrument in use in the world. Both of the great American telescopes are devised solely for visual purposes, and can only be used for photography by the aid of auxiliary lenses which cut off some of the light.*

Among other large objectives may be enumerated the Pulkova refractor, at St. Petersburg, by Clark, diameter 76 centimeters, objective of the Observatory of Nice, of equal diameter, by Henry Brothers, of Paris; the objective of the Vienna Observatory, of 71 centimeters aperture, by Martins, and the Treptower objective, of 70 centimeters aperture, poured at Jena, ground in Munich

* The Yerkes telescope is used as a photographic instrument by interposing in front of the plate a color screen for removing the violet rays and exposing plates sensitive for the yellow rays.

(1896), and costing 55,000 marks.

The objective of the Dorpat refractor, with twenty five centimeters aperture, which, as it came from the master hand of Fraunhofer, was regarded as a wonder of the world, can scarcely be counted among the large telescopes to-day, for already more than 100 exceed its dimensions. It would lead too far to mention them all, but it is not out of place to remark that there is work of great value also for the smaller lenses. Interesting studies of the features of the planets have been made even in recent times with smaller instruments. Thus Schiaparelli, the famous discoverer of the so-called Martian canals, made his earlier valuable observations with an 8-inch telescope, which would now be classed as a minor instrument. In planetary observation the advantages of fine optical definition, together with good atmospheric conditions, combined with practiced eyes, are of more consequence than high power or great light-gathering capacity. The advantages of the largest instruments lie in the possibilities they afford of observing the fainter fixed stars and nebulæ which lie at immeasurable distances.

## TOTAL ECLIPSE OF AUGUST 30, 1905. OBSERVED AT BURGOS, SPAIN.

CHARLES P. HOWARD.

For Popular Astronomy.

The writer observed the eclipse at Burgos, Spain, in company with Dr. Charles S. Hastings of New Haven, Conn. Both made visual observations only, through nearly identical small telescopes, of low power and wide field of view. My own telescope had an aperture of 3½ inches, a magnifying power of 20 and a field of view of 2.1 degrees. The telescopic seeing was perfect, as evinced by the following facts: Close to the Sun the sky was deep blue in color, indicating complete absence of haze, and the surface of the Sun seen half an hour before totality, through a 4½-inch telescope with power of 60, showed a quality of definition only to be had under the most perfect atmospheric conditions. This telescope although mounted parallel to the smaller one was not used to observe the Corona, for reasons which will appear below.

The chief phenomena visible to the naked eye were these: About three minutes before second contact, it was raining; one minute later, the sky cleared around the Sun, and it stopped raining. The Sun was then an extremely thin and short crescent on an

intensely dark blue sky, and several light clouds that floated near it showed brilliant irridescent colors. The shadow bands on the ground were very conspicuous. The Moon's shadow was plainly seen coming from the west, being dark blue with sunset colors in the air under and around it. Near the Sun the sky remained perfectly clear until about ten minutes after third contact, so that during the critical three minutes and forty seconds of totality the atmospheric conditions were absolutely perfect.

During totality, to the naked eye, the Corona appeared a ring of dazzlingly white light, about one quarter radius of the Sun wide, surrounding the black disc of the Moon; its outer edge was not evenly circular but appeared stellated. This part of the Corona was so dazzling to the eye that nothing beyond it was visible. The sky at this time was nearly three quarters covered with clouds; overhead it was quite dark and gloomy but all around the horizon, were luminous sunset colors seen between the clouds; so that during totality the darkness was not very great.

To the naked eye this eclipse, occurring at the maximum of solar activity, did not compare in beauty with that of 1900, which occurred at the minimum of solar activity.

Through the 3½-inch telescope I wished particularly to examine the structure of the corona near the Sun's poles. Knowing that at the maximum of solar activity the Corona surrounds the Sun much more uniformly than when the solar activity is at its minimum, I expected to find this Corona quite different from that of 1900. Notwithstanding this expectation I was completely taken by surprise to find it distributed all the way around the Sun with such uniformity, that there was nothing at all to indicate any difference of structure between the polar and equatorial regions, by which to determine the position of the poles. Knowing by previous calculation that the apparent position of the Sun's pole (inverted) lay a few degrees to the left of a vertical line through the Sun's center, and finding nothing there in confirmation, I concluded that a mistake must have been made in my figures. I then looked three times all the way around the Sun without seeing any form that gave the slightest hint as to where the Sun's poles were, except that a considerable distance to the right of the vertical, there was a small and inconspicuous group of three or four curved whisps, concave to the left, that looked like polar brushes, but entirely out of place and turned the wrong way, these objects thus situated added to the perplexity. I therefore gave up trying to locate the poles, and assumed that they

could not be far either to the right or left of the vertical line.

I then carefully examined the Corona near the upper limb of the Sun, for objects similar to those seen by me in 1900 at the Sun's poles, but not a single object corresponding to any of those thus seen at the previous eclipse was visible. There was absolutely nothing in the Corona to suggest magnetic force in the Sun, which was such a prominent feature of the Corona of 1900. The whole field of view out to 2½ radii from the Sun's limb was plainly seen to be a filamentous structure, of such a complicated nature that no description or drawing of it could be made, even immediately after the eclipse. The filaments were perfectly easy to see, but were so fine as to be nearly at the limit of vision. They were brighter near the Sun and gradually grew fainter as their distance out became greater until beyond about 2½ radii from the Sun they were too faint to be seen. They did not noticeably extend out further in one direction than in any other. A very remarkable feature of this whole filamentous structure was that it seemed to be lying in a plane at right angles to the line of sight. This appearance was very marked. The filaments did not lie radially or nearly tangentially nor did they interlace. I did not notice how long the filaments were, except in the upper left hand part of the field of view, where they were seen to be about ½ radius of the Sun long. The color of all was uniformly white. They did not bunch into the form of whisps, wings and horsetails, nor show perspective as in 1900. They had a more feathery look (a rather indefinite expression) and were somewhat more difficult to see.

During the three times that I looked around the circumference of the Sun, as mentioned above, the filamentous structure of the whole Corona was seen with perfect distinctness, and each time, besides the filaments, three definite objects and those only were plainly visible.

The first object, was a very conspicuous dark ray that seemed projected radially from the upper right hand limb of the Sun, as far out as the luminous filaments afforded it a visible back-ground. At the limb of the Sun its width was about one tenth the radius of the Sun. Both edges were sharply defined and their directions were nearly radial, but my recollection is that they were slightly less divergent than this would make them. Its appearance was similar to the straight beam of light that appears to be projected from a search light on a hazy night, but dark instead of light. This dark beam was very remarkable and its nature seems wholly inexplicable; it will probably show well on the photographs of

this eclipse. With the telescope used, it appeared as structureless as if it were a shadow thrown across the apparently flat filamentous surface of the Corona.

The second object, was a group of three or four curved whisps like little polar brushes already described. These stood a little to the left of and above the place where the dark beam was projected from the Sun, and they curved away from it as if repelled by a force acting in a direction away from the dark beam. Their color was white and their surfaces looked flat and as if they were not composed of filaments.

The third object, had the general appearance of a small piece of white slag or scum. It was bent to be concave towards the Sun, and was accompanied with another much smaller piece also bent in the same direction and located within the concavity of the first. It was situated to the left of the Sun at a distance of rather less than one radius from the limb. It had a very strange appearance, more as if it was a solid substance than anything I have before seen in the Corona. Just before third contact I looked at it again. A power of twenty was too low to show it well, and I was about to look at it with the 4½-inch telescope (power of 60) when the Sun appeared and put an end to further observations.

Prominences although not large were very brilliant, particularly a row of four or five which stood out from the eastern limb of the Sun. No attention however was paid to them.

As seen through the telescope also, this eclipse did not compare in interest and beauty with that of 1900.

Hartford, Conn.
October 19, 1905.

## ASTRONOMY IN THE HIGH SCHOOL. IV.

## PATHS OF HEAVENLY BODIES AMONG THE STARS.

MARY E. BYRD.

FOR POPULAR ASTRONOMY.

Those who watch the heavens without optical aid see the stars set like jewels in an unchanging pattern. Centuries even millenniums pass, but the grouping of the stars remains the same. By whatever names they are called, there are still the Northern Crown, Cassiopeia's Chair and the Milk Maid's Dipper.

It is upon this changeless background that we see the paths of all moving bodies projected. The Sun, on account of its brightness, cannot be located directly among the stars. Perhaps

the best way for beginners is the old way, to watch in the west for the first constellation that appears in the waning twilight along the course that the Sun has just travelled. Later when instruments are employed, and the Sun's noon altitude measured, a more accurate position may be obtained by means of the celestial globe. Let it be oriented for the latitude of the place and the time of observation, then the observed altitude read off on the globe fixes the Sun's position closely with regard to neighboring stars.

Of the many naked-eye problems connected with the Moon, none is more interesting than laying down its path among the stars. Inexperienced students with average eyesight often have difficulty in detecting the motion of a planet, but of the Moon they say "Why, it moves." For them the general rule should be to find out in what constellation the Moon appears, or if possible in what part of a constellation, every evening when it is above the horizon, clouds permitting.

By aligning from bright stars some distance away, this is easily done, even when the Moon is nearly full, as is shown by the following observation.

"94 State Street, Northampton, Mass.,
June 15, 1905, $10^h$ P. M., Eastern Standard Time.

Draw a line from Spica to Antares and at the latter star erect a perpendicular to the line equal in length to 2 ($\alpha$ *n*) Boötis or $\alpha$ $\delta$ Ursae Majoris. Place the Moon one degree east of the end of this perpendicular."

The point found on the globe from these directions lies within a third of a degree of that given by the Ephemeris, an agreement which is called "too close" because it is closer than any one would have a right to expect from this method of observing and checking. Students' determinations may be in error two or three degrees and still give a vivid and fairly correct notion of the Moon's monthly circuit of the heavens.

To locate the Moon as accurately as possible by the eye estimates favorable times must be chosen. If the weather is propitious, there come between new Moon and first quarter, a few ideal nights when the time of setting is late enough for stars to emerge from the twilight and the crescent is yet too small greatly to dim their light. It is not difficult then to get a good position of the Moon by referring it to faint stars quite near. Thus, three things are obtained, an accurate point in its path, one of the two observations needed to find its hourly rate of motion, and also one of the positions for finding the number of days it takes to pass

entirely around the heavens from a particular star back to the same star again.*

Each of the five bright planets, Mercury, Venus, Mars, Jupiter and Saturn has its individual characteristics and must be studied in reference to them. The first hovers always so near the Sun that often its path must be reduced to a single point. Nor can this one be obtained directly from the stars, for in our latitude Mercury sets before the stars come out. Any appliance, however, for measuring altitude and azimuth gives the essential data. The coördinates thus obtained should be plotted on the globe, after it has been properly oriented, and then from the globe, as from the sky, a sketch may be made showing the position of the planet in relation to neighboring stars, or its right ascension and declination may be read directly. It is well to employ this method in early twilight observations of all planets, especially of Venus. By combining direct and indirect star-comparisons quite a considerable arc may be traced for this the brightest of all the planets.

In mentioning different ways of finding positions, the cross-staff should not be overlooked. Experience in using this historic instrument enables one to obtain rather more accurate places than those found by the unaided eye. Still it would be highly undesirable if either the cross-staff or altazimuth instrument should usurp the first place in observing. Two things of the utmost importance to our students are gained by direct estimates, the eye is trained to a fair degree of precision in judging of distances and directions in the heavens, and this training lies at the foundation of all success in elementary astronomy. Then, too, the habit is formed of getting large views of the heavens, seeing moon, planets and stars as a comprehensive whole, and noting many points of interconnection and relation. Any one who makes many instrumental measures soon sees nothing but the one or two bright points under observation.

The motions of Jupiter and Saturn are slow and stately as befits the largest of the Sun's attendants. Watches extended over a number of weeks often give only very short arcs of their paths. But because difficult to follow they should not be left out It is worth a good deal of pains and effort on the part of both teachers and students to win for the latter the happy triumph of proving that they do move, and that their motion changes from east to west and vice versa.

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* See the writer's "Laboratory Manual in Astronomy," § 144,

Mars when favorably situated, in alternate years, is preëminently the beginner's planet. Its bold march across the heavens as it carries its fiery red light from one constellation to another rouses the interest even of those who look at the heavens with unseeing eyes.

A somewhat careful method of fixing its place among the stars is illustrated by the following actual observation.

S. C. O., Northampton, Mass.,
9$^h$ P. M. Eastern Standard Time, June 8, 1905.

I located Mars in the constellation Libra by estimates made directly with the unaided eye.

(1) $\alpha\gamma = 2\,(\alpha\,\sigma)$, $\sigma$ west of $\alpha$
(2) $\angle\,\beta\,\alpha\,\sigma = \angle\,\iota\,\alpha\,\sigma = 1\frac{1}{2}$ rt. $\angle^s$
(3) $\angle\,\gamma\,\alpha\,\sigma = 2$ rt. $\angle^s$, i. e. st. line nearly.

(H. A. R.)

This position checked, as usual, on the globe varies only a tenth of a degree from the Ephemeris declination, but nearly a degree from the right ascension. Checking, however, on almost any celestial globe may involve an error of half a degree or more.

A graphical representation of all points located, by whatever method, is hardly less important than the observations themselves. The first step is to prepare a careful chart, preferably on heavy cardboard, containing a section of the ecliptic and a number of bright stars along the course of a particular body. This chart should be on a much larger scale than the small maps used by students, and should include other stars as well as those used by every member of the class. It then devolves upon all who have followed the motion of the given body to enter in their note books a tracing-paper copy of the chart. This is their skeleton map upon which with the greatest care they are to fix the different points determined by the data of the individual observations. A smooth curve drawn through these points shows at a glance the actual path in the sky, watched from night to night. Interesting deductions follow, especially if several paths can be compared, their positions in reference to the ecliptic, the constellations traversed, bright stars passed, direction and rate of motion and corresponding changes in right ascension and declination.

The methods which have been outlined for locating the paths of heavenly bodies are less complicated in actual use than in written description, but if our students are young and immature, it may be wise to begin with simpler exercises. Note-taking which it is never permissible to omit, may then take the following

rather unscientific form.

"Lawrence, Kansas, August 1905.

About the middle of the month, I noticed that Jupiter was in Taurus, in line with the Pleiades and Aldebaran, and midway between them. Before the end of the month it had moved out of this line to the east, and was nearer Aldebaran. Mars, meanwhile, was moving much faster, for in the latter half of the month it passed nearly across the fan-shaped figure in Scorpio, going toward Antares."

As astronomers reckon comets, one must be pretty bright to be anything more than a curiosity to beginners. The last to meet this test appeared three years ago, growing bright early in the fall, and so the class then beginning astronomy at this observatory were introduced to "comet b, 1902" on the first evening of their observing. The weather was unfavorable the following month, and there are difficulties in teaching students to map a comet in reference to the stars, when they hardly know one constellation from another. Still, in spite of drawbacks, the class of more than thirty under the efficient leadership of their instructor, Miss Louise Barber, obtained a number of comet places, four fifths getting three or more positions and half the class four or more. Their first plotting was done on the celestial globe. The smallest arc observed by any one student extended over 30°, the largest over 84°. Almost every one had data for determining how the comet was moving with regard to the Sun, how its velocity compared with that of other bodies, whether one week it was moving faster than others, its course through the constellations and the position of the path traced with regard to the ecliptic.

The path finally plotted was made on a specially prepared star-chart, like that described above and so formed a permanent part of the note book record.

Such laboratory work as this with every individual of a class doubtless seems slow and tedious to some, but it is surely worth while, if first-hand knowledge in astronomy as in other sciences, is of value; and I venture to think that it is, though sometimes when energetic efforts bring rather meagre results, I remember what one of my students frankly told me "I wish to drop astronomy and take some other study, one can get along so much faster reading books."

## THE TIME OF MOONRISE.

Wm. F. RIGGE, S. J.

For Popular Astronomy

On account of the Moon's rapid motion both in right ascension and in declination, the computation of the times of the Moon's rising and setting is apt to prove very laborious, since it cannot be done except by successive approximations. The object of this article is to explain a very rapid method to be used for this purpose. While it may be an old one, the writer's reason for presenting it is that he has never found it in print.

The method to be described is a graphic one and requires in advance the construction of three diagrams, which we may denote by the letters A, B and C. In order to show their practical use, they have been prepared for Omaha, Nebraska. The problem before us, therefore is to find the central times of moonrise and moonset for Omaha.

1. The first thing to be done is to find the time of the Moon's meridian passage. This is given for Greenwich on page IV of every month in the American Ephemeris. To reduce it to Omaha and to central time, we must add to it 6.4 (the Greenwich longitude of Omaha being $+ 6^h\ 23^m.8$) times the hourly difference there given, plus 23.8 minutes. This is done rapidly by means of diagram A, whose construction needs no explanation. Thus for January 13, 1906, when the time of the Moon's transit over the meridian of Greenwich is $14^h\ 58^m.4$ and the hourly difference is $2^m.13$, we find that 2.13 on diagram A indicates something over 37 minutes, which added to the Greenwich time gives $15^h\ 36^m$ as the central time of the Moon's transit at Omaha.

2. The next step is to find the Moon's hour angle. This is shown on diagram B for Omaha, the latitude being $+ 41° 16'$. The formula $\cos \tau = - \tan \phi \tan \delta$ gives the true hour angle, which must be corrected for refraction and parallax. For purpose of prediction it is evident that only the mean refraction of $36'$ can be taken. Special computation will show that this diminishes the hour angle $3^m.1$ for all values of $\delta$ between plus and minus 30°. For the parallax the mean value of $57'.6$ may always be used, since its extreme values differ only $3'.7$ from it or less than one fifteenth of its amount. As the parallax increases the hour angle while refraction diminishes it, the combined effect of both is to increase the Moon's hour angle by two minutes. Accordingly all the hour angles on diagram B have been increased by this amount. No variations from the mean values of the

refraction and parallax used in the construction of this diagram, can ever change the hour angle one third of a minute. No correction for semidiameter has been applied. This would diminish every hour angle at Omaha a minute and a half for the upper limb, or increase it as much for the lower.

Entering the Ephemeris on pages V—XII of the month with the central time of the Moon's meridian passage at Omaha increased by 6 hours (that is, the Greenwich time, $15^h\ 36^m + 6^h = 21^h\ 36^m$) on January 13, 1906, we find the Moon's declination to be about 9¾° north. I say about, because at this stage the fraction of a degree is of no importance. With this argument of 9¾° north, we find that on diagram B the Moon's approximate hour angle is $6^h\ 37^m$. This is written under the time of the Moon's transit $15^h\ 36^m$, and subtracted for rising and added for setting. With the results, $8^h\ 59^m$ and $22^h\ 13^m$, increased by 6 hours (to obtain the Greenwich times, $14^h\ 59^m$ and $28^h\ 13^m$) we make a second approximation and apply to the diagram the Moon's declination at these times as found in the Ephemeris. We write down under $8^h\ 59^m$ and $22^h\ 13^m$ only the difference between the first and the second hour angles found on diagram B, $-4^m$ and $-4^m$ in the present instance. Experience will soon show what fraction of a degree of the Moon's declination it is necessary to take in order to get the hour angle correct to the minute. If any care at all has been taken about the first value of the Moon's declination, the corrections $-4^m$ and $-4^m$ to the first approximate hour angle will agree numerically within two minutes and will have the same sign, which will be plus when the Moon is going north and minus when going south.

3. The third step is to correct the time of the Moon's rising and setting for its motion in right ascension. This is done by means of diagram C, which is merely a graphic method of multiplication. The vertical lines marked 4, 5, 6, 7, 8, indicate the Moon's hour angles, and the oblique ones 1.50, 2.00, 2.50, 3.00, the hourly difference of the times of the Moon's meridian passage as given on page IV of the month in the Ephemeris. With these two are arguments, $6^h\ 37^m$ and $2.^m13$ in the example selected, we find from the horizontal lines marked 5, 10, 15, 20, the correction sought, which here is 14 minutes. This is to be subtracted for rising and added for setting, and is the same numerically for both.

As the correction of diagram C may amount at times to 20 minutes and more, a third approximation would seem to be necessary. In declination this is inappreciable, since the maximum change of the Moon's declination is less than one third of a degree

in an hour, and in twenty minutes it would never affect the Moon's hour angle on diagram B to a noticeable fraction of a minute. In right ascension however, the twenty minutes when added to the same hour angle that was used to find them on diagram C would entail a second correction of a full minute when the hourly difference is 3.00, a limit which it never reaches. But as this second correction often exceeds half a minute, the hour angle may at once be increased by the amount of the first correction and another found from the diagram. It would not be advisable to reconstruct diagram C for the purpose of avoiding this additional labor, since, as will be said later, this error effects only the time of the Moon's setting at Omaha, and never that of its rising.

4. Adding up our quantities algebraically, we obtain $8^h\ 41^m$ and $22^h\ 23^m$ as the astronomical central times of the Moon's rising and setting at Omaha on January 13. Changing these to civil central times, we find that the Moon rises on January 13 at 8:41 P. M. and sets on January 14, at 10:23 A. M. A day will be found to drop out for rising as well as for setting whenever the times change from P. M. to A. M., that is, cross midnight.

January 13, 1906.

| Rising | Setting | |
|---|---|---|
| $15^h\ 36^m$ | | Meridian passage, central time, A |
| $-\ 6\ 37$ | $+$ | Approximate hour angle, B |
| $8\ 59$ | $22\ 13$ | Approximate times |
| $-\ 4$ | $-\ 4$ | Correction for change of declination B |
| $-\ 14$ | $+\ 14$ | Correction for change of right ascension C |
| $8\ 41$ | $22\ 23$ | Astronomical central times |
| $13^d\ 8{:}41$ P. M. | $14^d\ 10{:}23$ A. M. | Civil central times |
| $8^h\ 40^m\ 39^s$ | $10^h\ 21^m\ 59^s$ | Numerical computation. |

Accuracy. The diagrams, especially A and C, may be used to tenths of a minute, if desired. But the nearest whole minute is sufficient accuracy in practice, since the horizon is often obstructed by terrestrial objects or dimmed by smoke, the weather is unpropitious, and most of the times of moonrise and moonset occur during the day time and at inconvenient hours during the night, so that only such a small percentage of the computed times are actually observed that more accurate and time-consuming computation would seem to be only so much labor wasted. As three diagrams are used, and the nearest minute is taken in each one, it may happen that in each case nearly half a minute is neglected and that in the same way, and therefore the results may be erroneous by more than a full minute. This is certainly possible and must occur at times, but it is just as likely that

these fractions of a minute may have contrary signs and annul one another.

No account need ever be taken of second differences in the times of the Moon's meridian passage. For Omaha the Moon always rises within two hours and a quarter of its upper transit at Greenwich, so that the errors of these diagrams A and C counteract one another. But as the time of the Moon's setting occurs within two hours and a quarter of the Moon's lower transit the errors of these diagrams are additive. An examination of the Ephemeris of 1894, when the Moon's ascending node was near the vernal equinox and the Moon therefore reached a declination of over 28°, showed the maximum second difference between two successive days to be 0.24 minute. For an interval as great as 16 hours from the time of the Moon's upper transit at Greenwich, only one third of this, or 0.08, would be effective, and this amount for the maximum hour angle eight hours would be only about 1.2 minute. As this is a most exceptional case, it is safe to say that, in general, the accuracy of this method is to give the times within a minute. This estimate was confirmed by a more rigorous numerical computation of this same example of January 13, 1906, which was selected at random, and in which the Moon's right ascension and declination, the sidereal time, and other necessary quantities were used and the same result was obtained practically within a minute.

Speed. The speed is such that I generally compute the times of both rising and setting for a whole month in less than an hour, and sometimes even in less than 45 minutes.

Creighton University, Observatory.
Omaha, Nebraska.

## THE POLARIS VERTICAL CIRCLE METHOD AND THE ENGINEER'S TRANSIT.

F. H. SEARES.

For Popular Astronomy

In a recent article by Dr. G. O. James,* entitled, *On the Polaris Vertical Circle Method of Obtaining Time with the Surveyors Transit*, the following statement is made: "Professor Seares has adapted the method to the engineers transit, and has given the necessary formulae for the reduction. Where the object is to obtain as accurate a value of the time as is possible with the

* *Popular Astronomy*, XIII, 499.

instrument at hand his method is all that can be desired. When, however, an approximate value of the chronometer correction is wanted, as for instance in azimuth work, the following method of reduction will be found much shorter."

It is true that my *final* formulæ for the clock correction were designed to secure all the precision that the engineer's transit is capable of affording; but the statement just quoted overlooks entirely the fact that I have suggested, and actually used, an obvious simplification of my final formulæ in order to arrive at the very result obtained by Dr. James, namely, the determination of a value of the clock correction which shall not be in error more than one or two seconds. Further, the assertion contained in the last sentence is misleading, inasmuch as it gives an impression that the method proposed by Dr. James involves something essentially different from my own, with a consequent saving in time and labor. His method of *deriving* the formulæ to be used in the reduction *is* different from my own, but I shall show in the following pages:

(1) That, with the exception of a single factor, his final equations are identical with what my own final formulæ become when the effect of collimation is neglected.

(2) That I have already made use of such a simplification in my paper, for the approximate determination of the clock correction.

(3) That, in so far as there is any difference between his formulæ and mine, collimation being neglected, the advantage is in favor of my own.

In order to compare the two sets of results I shall suppose that in both cases a sidereal chronometer has been used. Further, I shall assume that only a single approximation is necessary in order to obtain the clock correction within the desired degree of accuracy. Such an assumption is evidently legitimate for the comparison, since the arrangement of the approximations and the rapidity of the convergence is exactly the same for both cases.

With this simplification the equations of Dr. James assume the following form:

(A)
$$\begin{aligned} t_0 &= \theta_0 - \alpha_0, \\ q_0 &= p_0 \sin(\phi - \delta) \sec\delta \sec(\phi - \epsilon_0), \\ t &= -q_0 \sin t_0, \\ \theta &= \alpha + t, \\ \Delta\theta_c &= \theta - \theta_c, \end{aligned}$$

where $\Delta\theta_c$ is the error of the clock.

In my own method the clock correction is given by $\Delta\theta'$ when

the collimation is neglected. The necessary formulæ are therefore:*

(B)
$$\begin{aligned} \tau_0 &= \alpha_0 - \theta_0 - \Delta\theta_0, \\ a_0 &= -\pi\, G \sec\phi \sin\tau_0, \\ A &= \sin(\phi - \delta)\sec\delta, \\ \Delta\theta' &= \alpha - \theta - a_0 A \end{aligned}$$

From (A) there results, by substituting the second, third, and fourth equations into the fifth,

(C) $$\Delta\theta_c = \alpha - \theta_c - p_0 \sec(\phi - \epsilon_0)\sin t_0 \sin(\phi - \delta)\sec\delta.$$

From (B) there results, by substituting the second and third equations into the fourth,

(D) $$\Delta\theta' = \alpha - \theta + \pi\, G \sec\phi \sin\tau_0 \sin(\phi - \delta)\sec\delta.$$

But we have the following correspondences in notation:

| Seares | | James |
|---|---|---|
| $\Delta\theta'$ | = | $\Delta\theta_c$, |
| $\theta$ | = | $\theta_c$, |
| $\pi$ | = | $p_0$, |
| $\tau_0$ | = | $360^c - t_0$. |

whence it follows that equations (C) and (D) are identical, excepting for the occurrence of the factor $\sec(\phi - \epsilon_0)$ in the former where the latter has $G \sec\phi$. With this exception, therefore, the two methods of reduction are the same.

Again, I have indicated in my paper, page 79, lines 11-12 and 27-30, that the value of $\Delta\theta'$, derived from a single star, gives an approximation for the clock correction. In the printed example, page 83, $\Delta\theta'$ has been computed for the second star and used as such an approximation in deriving the final results for that example. The value of $\Delta\theta'$ thus calculated is $+ 8^m\ 43^s.8$. The final value of the clock correction for the second star, derived from the complete formulæ, is $+ 8^m\ 43^s.3$. Although the closeness of this approximation is not emphasized, since the example was intended as an illustration of the complete formulæ, it is obvious, nevertheless, that for many purposes it will be sufficient to observe a single time star and stop the reductions when the value of $\Delta\theta'$ has been obtained. This is precisely what Dr. James proposes.

Finally, since the fundamental equations for the two methods of reduction are the same, with the exception of a single factor, it is evident that the relative advantage of the two methods hinges entirely upon the calculation of this factor. In Dr. James' method its form is $\sec(\phi - \epsilon_0)$; in my own, $G \sec\phi$. It is not a question of accuracy, but of ease and rapidity of computation, for, numerically, the two expressions are equal, at least within the set limits of error. To calculate the former, three operations are necessary:

* *Laws Observatory Bulletin.* No 5, p. 81.

(1) Take $\epsilon_0$ from Table IV of the *American Ephemeris* with the argument $t_0$.

(2) Form the difference $\phi - \epsilon_0$.

(3) Interpolate the corresponding value of log sec $(\phi - \epsilon_0)$ from a logarithmic table.

On the other hand, the determination of $G$ sec $\phi$ involves but a single operation, namely, an interpolation from a table consisting of only thirteen numbers and covering only a small fraction of a page. To be sure, such a table must be calculated for the place of observation, but this is a matter of only four or five minutes and can be done once for all. It requires only that the value of log sec $\phi$ for the place of observation be added to the values of log $G$ contained in Table V, page 82 of my paper. $G$, itself, is not independent of the latitude, but neither are the tabular values of $\epsilon_0$ given in the *American Ephemeris*. The quantities $G$ and $\epsilon_0$ are upon the same basis in this respect. Both vary slowly with the latitude; both have been computed with a mean value of this quantity, and the tabular values of both can be used for all cases that are likely to arise in practice. It is evident therefore that the calculation of $G$ sec $\phi$ can be more quickly accomplished than that of sec $(\phi - \epsilon_0)$.

For a single example the difference in labor is not worth serious consideration; but when the same operations are to be repeated over and over again, such apparently insignificant points become of serious consequence, and it is on this account that I have discussed the matter in such detail.

The tabulation of the values of log sec $(\phi - \epsilon_0)$, with the hour angle as argument, naturally suggests itself as a possibility; and if this be done, Dr. James' method becomes the exact equivalent of my own, in so far as any single place of observation is concerned. But when it becomes a question of using the method at different places of observation, the form $G$ sec $\phi$ for the factor in question in still the more advantageous, since the tabulation of log $G$ sec $\phi$ in the manner I have suggested requires less time than the tabulation of log sec $(\phi - \epsilon_0)$,

Laws Observatory, Columbia, Missouri.
Nov. 9, 1905.

## ON MAKING NEGATIVE ENLARGEMENTS.*
## II

WALTER ZIMMERMAN.

A simpler method of obtaining modifications than subsequent

* British Journal of Photography, No. 2370.

work of any kind is to obtain local reduction or intensification in the exposure of the positive. I mean by this that if in the original negative, there is a portion which prints too dark, it can be corrected in making the enlarged positive. A piece of paper a little smaller than the enlargement of that part should be cut out and pasted on a large piece of glass. This paper mask may be held in front of the very thin part of the negative during part of the exposure. If there is a part of the original which is much too dense, a hole may be cut in a large piece of black paper the shape of the dense part, but smaller, and the paper held midway between the lens and the plates in the frame. This will hold back all of the rest and force full detail from the refractory portion.

If clouds are wanted and are lacking in the original, they may be "wiped in" on the paper backing in a way to be further described, or else printed in from another negative. To do this latter most successfully, arrange everything for the exposure except adjusting the plate. Fasten a piece of cardboard larger than the plate to be used on the easel, and have its position accurately registered as by thumb-tacks. With the lights turned out and with the projected image on the card, trace carefully the horizon line of the original negative as enlarged, and leaving the registering pins or tacks in place, cut the card in two, following the line. With the two pieces of card used alternately expose the original for the lower part and the cloud negative for the sky. If accurately done there should be no more than a hair-line to be retouched in subsequently. The same method may be used with one negative where the clouds are very dense, in that way holding back the thin part of the negative more accurately than by ordinary shading or masking. The proper effect will then be obtained on the negative without having to resort to any shading in making good prints from the large negative.

The objection to making changes from the actual atmospheric effect at the time of exposure is that false lighting is likely to be caused, rendering the "picture" worse than useless. To the pictorial worker whose first and last aim is a picture the modifications in negatives are perfectly legitimate. In fact, it has become assumed that pictorial photography means photography aided by the mind and hand. The question of honor comes in only when the photographer claims the effect to be untouched—for instance, in a contest in which unretouched work is expected and required.

With the positive ready for the contact exposure, examine it

carefully to determine the exposure, and to decide upon the effect required in the final negative. The exposure in contact work may be easily learned. There should be a shelf a few feet from the source of light and on a level with it for the center of the plate. The light must be uniform; a gas-jet always turned on full; a Welsbach, always in good order; or an incandescent electric light. A trail should be made to learn the printing time either with a small plate of the make to be used or with a strip of bromide paper, covering portions and giving timed exposures, as suggested in the last article. The ratios between the paper and the plate here given may then be used to determine the exposure of the plate. If cost is not important it is still better to sacrifice one plate on an experimental exposure in sections. In loading the printing frame for the exposure, it should be placed slanting on a shelf so that there may be the least possible opportunity for dust on the transparency. Then place, first the transparency and then the new plate in position film to film. For diffusion, use the separators which come in the plate box. A piece of black paper between the plates and the backboard of the printing-frame will obviate any possible halation. Should any part of the positive be too dense, incline the frame with that part toward the light. The negative so made should print perfectly. The time of the first satisfactory print in bright sunlight should be carefully noted and marked in one corner of the negative. All subsequent prints made under the same conditions should be uniform and the wasting of large paper will be unnecessary.

The method of making negatives for exhibition work by contact, using bromide enlargements, I believe is an original one. At any rate the process is exceedingly interesting and has several advantages: Economy, in the use of but one large plate; certainty, on account of a uniform exposure being given for all negatives; and third, it is a method by which modifications and corrections may be made with greater ease than by using glass positive. In giving a detailed description of the process I would prefer to avoid personal references, but can tell the story more clearly and intelligently if I take one of my negatives and describe the means by which it was made. Let us then take the negative, 18 by 22 inches, of the picture called "Saint Anne's Day," representing the interior of a church in Brittany, with the congregation of women in their white Breton caps. The original film was made with a Kodak. I had held the camera as high as I could reach against the rear wall of the church, gauging the distance at 75 feet, and stopping down about one-half in order to bring into focus far

and near points. The shutter was opened and closed with the hanging bulb, the exposure being a little over half a minute. During the time, absolutely necessary on account of the "dim religious light," many of the heads had moved, no one else knowing that a photograph was being taken. There was, therefore, a great deal of blurring in the lower part of the film, and when the negative was magnified the effect was, of course, very bad indeed. The lighting was also very irregular, being in excess in the upper part of the church and on the white caps of the women. The paper used for the enlargement, the same size as that of the plate intended to be made, was thin, smooth bromide, which has a very regular texture and a surface well adapted to the use of the pencil.

The whole negative was first exposed for the time required to print the thin portion, then a piece of cardboard was held in front of the thin part as shown on the screen, and moved slowly upward as the lighting in the film gradually increased towards the top. The upper part of the bromide paper was in that way exposed two or three times as long as the central part. Then, with two pieces of cardboard, the whole of the image was covered except where the heavy high-lights of the caps appeared in the lower part of the film. This brought out the detail which otherwise would have been lacking. It will readily be understood that if a bromide enlargement had been made without these precautions the central part of the church would have appeared very black, or else the top would have been white and the caps mere white patches. The print when developed, proved to have been exposed to represent uniformity of lighting, or as if there had been windows in the lower part of the building instead of at the top alone. After washing, the print was fastened to a flat board by means of thumb-tacks, so that in drying it was stretched flat and smooth. I now use, instead, a strong solution of glycerine, after which prints dry flat when hung up and have no tendency to curl.

The trouble commenced when it came to removing the many evidences of motion. A very few of the people had not moved, including one old woman who was standing, and these few deserved my benediction. The retouching materials consisted of a number of lead pencils of different grades of hardness. In some parts of the print, hair-lines were sufficient to make the corrections. In others it was neccssary not only to use the blackest pencil, but to put on all of the lead that the paper would take. When the print appeared to be finished, it was taken from the

board or easel and held up to a window so that it could be examined by means of the daylight passing through. There were still some places where the moving caps had left lighter patches. These places had to be worked up again on the white side of the paper. This was done by holding the print against a large window-pane. There were no insertions in the print, the only modifications being those for the lighting and the correction of the motion, both of which changes would be regarded as legitimate by the most earnest advocate of the doctrine of straight photography.

It is necessary in using this method to make sure that the back as well as the face of the print is free from marks or stains, excepting, of course, the retouching marks. Dirt or stain on either side of the paper will cause blemishes in the resultant negative. The materials required in making the negative are: A printing frame the size of the negative and a piece of clear glass to fit the frame. The clear glass is first placed in the frame, then the bromide picture with the white side next to the glass, and then the dry plate, coated side next to the film side of the print. The back is then clamped on the frame ready for the exposure. With a fast plate one does not obtain sufficient density on account of the thin emulsion of the paper, while a process plate would produce rather too harsh an effect. It is best to use but one kind of plate in all work by this method, and to learn the exposure and development of that plate as perfectly as possible.

To make the exposure, there should be a narrow shelf in the dark room about five feet distant from the white light. A screw-hook may be used to hold the heavy printing frame in place. All bromide prints, correctly exposed and developed, will receive a uniform exposure by this method. It is therefore important to find out precisely what that exposure should be by experimenting with strips of bromide paper. The preference between underexposing and overexposing would be to overexpose slightly in order to avoid the harshness resulting from prolonged development. Such harshness would cause the grain of the paper to show in both the negative and in prints from it. Strange as it may seem, a negative properly exposed and developed gives scarcely any evidence of the texture of the paper unless one prints on a slow gaslight paper, which of course he will not wish to do with work of this character. The plate being a very little overexposed, it should be normally developed so that the image will be nearly darkened out when development is complete. Considerable overexposure will produce flatness, so that the word "slightly" is

important. Development should be full, but not forced. The plate should be washed before development and the whole surface lightly rubbed with the hand to remove bubbles, which cause pinholes. The tray containing the plate should be rocked during the development to secure evenness. The result is worth the additional trouble. The negative should be carefully rinsed to avoid stains and then fixed. The best developer appears to me to be metol-hydroquinone.

This is the method which is usually employed by the experienced amateur photographers who are willing to take the trouble to make large negatives for their own use. The reference to it can be very brief, as the process is quite similar to that of enlarging on paper. It is not always the best looking transparency which gives the best negative. A positive made on a slow plate is apt to have more contrast than the original negative, and while such additional contrast may be very pleasing to the eye, too much harshness is apt to result in enlarging it to a negative. The right positive is usually a slightly overexposed one, developed for detail with a rather weak developer, such as diluted metol-hydroquinone. The positive must be made with the greatest care, as the most minute pinholes caused by air bubles or gas in old developer will, when magnified, cause the negative to be most unsatisfactory. An excellent way of printing a positive is to use a wax match and hold the small flame a little in front of the too dense parts of the negative.

The method which is usually employed by professionals in making large negatives is to first make a transparency enlargement of about one-half the diameter of the final negative and then make the final negative by a secondary enlargement from it. The reasons for this are twofold: First, some economy in plates and second, the professional feels more at home when all the work is done by enlargement rather than partly by contact; that is, he believes he can judge the exposures better when he sees the image thrown on the enlarging board. This method can be sufficiently learned from that which has been already written, so that no further reference to it is required.

Paper negatives can be classed with "freak" work, suited for certain purposes, but not to be depended upon for all-around use, either by the amateur or the professional. They have the great advantage of economy. The silver emulsion of bromide paper is much thinner than that of plates. As a result, a print from a paper negative is lacking in strength and gives a flat, faded appearance. The amateur who wishes to have a "low-toned" effect

may obtain it by using a paper negative. Suppose, however, that the matter of economy is an urgent one, the pictorialist not having the means or perhaps the opportunity of purchasing large plates, it is then a question of ascertaining the method of making the best possible paper negatives, for printing with sufficient contrast on any sun-printing paper. He should give the right exposure to obtain the needed detail, and, by using plenty of developer so as to keep the paper well covered from the air, give as long a development as will be possible without staining or fogging. In other words, he will aim to give the paper negative all of the "body" that can be obtained. He can work up the paper negative when dry by means of the pencil or charcoal, and in that way can frequently secure remarkably good results. A way of making these negatives with full contrast from flat originals is to work for contrast in the contact positive by using a slow plate or by prolonged development, or both. Another plan is to use gaslight paper instead of bromide, giving, with regular Velox paper, an exposure of minutes instead of seconds, as compared with bromide. This paper makes good negatives, although the increased contrast frequently makes the high lights unprintable. When the negative made by any of these processes is ready, the first print should be made in full sunlight and carefully timed. The suggestion has already been made that the time of a correct print in full sunlight should be marked in a corner of the negative with one of the blue marking pencils, so that all future prints may be correctly exposed without spoiling paper.

## PLANET NOTES FOR JANUARY 1906.

H. C. WILSON.

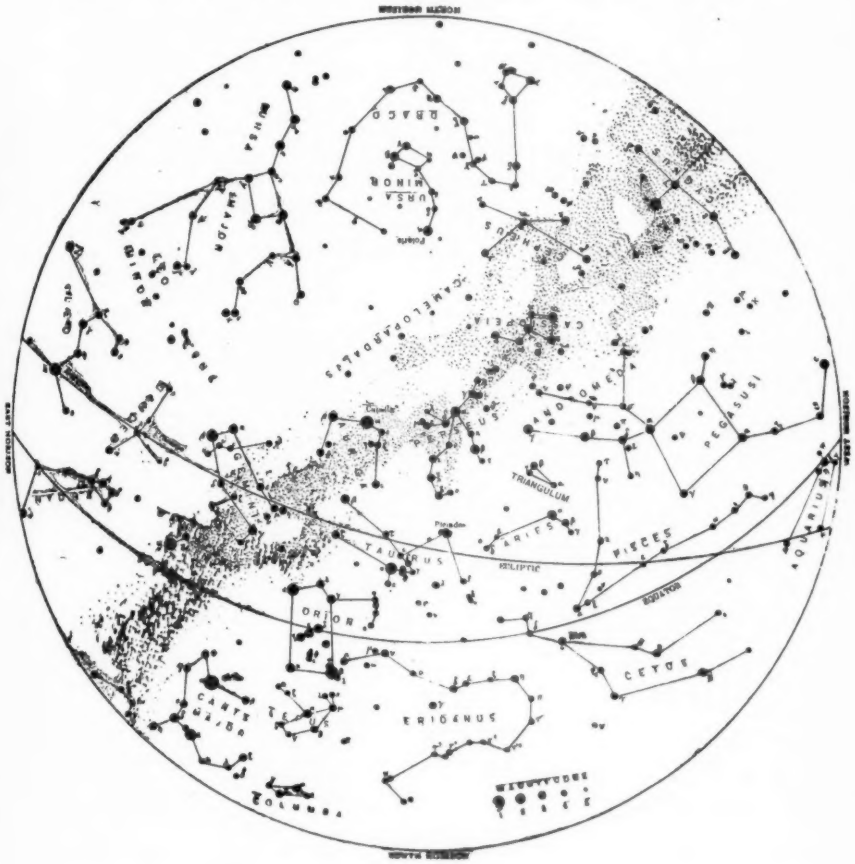
*Mercury* will be at greatest elongation, west from the Sun 23° 00′, on January 4, and will therefore be visible as morning star during the first week of the new year. The brightness of the planet on January 1, will be 47 as compared with its maximum brightness for the year 71. During the first two weeks in January the brilliancy will decrease from 47 to 31. On the mornings of January 16 and 17, it may be possible, with the aid of a telescope, to see Uranus in the same field of view with Mercury. The two planets will be in conjunction in right ascension January 16, at 8:00 oclock P. M. central standard time, Uranus being then 19′ south of Mercury.

*Venus* will be at superior conjunction February 13, and, although visible to the naked eye as morning star all through January, will not be in position favorable for observation.

*Mars* and *Saturn* form a fine pair of bright stars in the constellation Aquarius, the ruddy color of Mars contrasting well with the golden hue of Saturn. No stars as bright as the two planets are in this part of the sky, which is toward

the south west in the early evening, so that the observer will have little difficulty in identifying the planets. Both planets are in unfavorable position for telescopic observation, although the rings of Saturn may usually be seen as one ring under the worst conditions of atmosphere.

*Jupiter* is now in its best position for evening study, coming to the meridian at a high altitude at about nine o'clock. The planet will be almost stationary, about




THE CONSTELLATIONS AT 9 P. M., JANUARY 1, 1906.

5° directly south of the Pleiades, during this month. The belts of Jupiter are full of interesting details and the array of four bright satellites is always a pleasing spectacle to the uninitiated as well as to the experienced observer.

*Uranus* is nearing conjunction with the Sun and so cannot be observed, except perhaps as suggested in the note on Mercury. Uranus will be in conjunction also

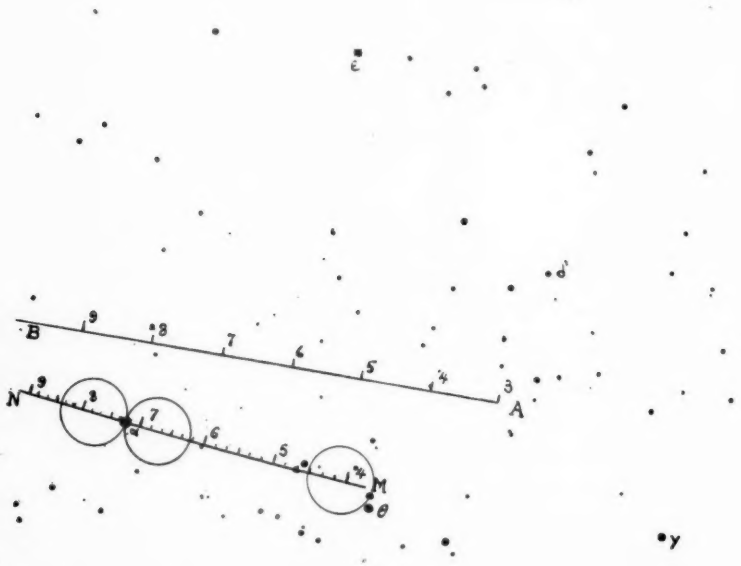
with Venus January 4, at 11:00 o'clock A. M. central standard time, at which time Uranus will be only 6′ south of Venus.

*Neptune* being just passed opposition is in best position for observation. This planet requires the use of a good telescope, with the aid of which it may be found among the faint stars, about 3° directly south of the star $\epsilon$ in the constellation Gemini (See chart in February, 1904, number of Popular Astronomy.)

**Occultations Visible at Washington.**

| Date. 1906. | Star's Name. | Magnitude. | IMMERSION. Washington M.T. h m | IMMERSION. Angle f'm N pt. ° | EMERSION. Washington M. T. h m | EMERSION. Angle f'm N pt. ° | Duration. h m |
|---|---|---|---|---|---|---|---|
| Jan. 2 | 33 Ceti | 6.1 | 7 04 | 71 | 8 31 | 231 | 1 27 |
| 4 | $\mu$ Ceti | 4.3 | 9 22 | 111 | 10 26 | 206 | 1 04 |
| 5 | BD. +12° 473 | 6.2 | 3 30 | 68 | 4 39 | 247 | 1 09 |
| 6 | 48 Tauri | 6.3 | 5 28 | 127 | 6 08 | 192 | 0 40 |
| 6 | 75 Tauri | 5.2 | 14 04 | 83 | 15 09 | 266 | 1 05 |
| 6 | Bradley 619 | 4.8 | 15 19 | 137 | 15 55 | 214 | 0 36 |
| 8 | 71 Orionis | 5.1 | 15 36 | 61 | 16 29 | 308 | 0 53 |
| 11 | $o^2$ Cancri | 5.7 | 15 9 | 161 | 15 57 | 236 | 0 48 |

**Occultation of the Hyades December 10, 1905.**—On the evening of December 10, the Moon will pass through the lower part of the Hyades, taking very nearly the same course as on the night of December 20, 1904 (See Popular Astronomy, November 1904). In the accompanying chart the line AB shows



the apparent course of the Moon's center as seen from the center of the earth; the line MN is the apparent course as seen from Northfield. The positions of the stars have been platted to the same scale by means of a photograph of the Hyades, enlarged and adjusted so that the principal stars $\alpha$, $\gamma$ and $\epsilon$ as platted to scale should coincide with their positions on the photograph. The times of the occultation of the various stars as seen from Northfield may be read approximately from the chart by cutting out a circle of the size of that on the chart and sliding its center along the line AB until the circumference touches the center of each star image.

The times of the occultations at Washington were given in the November number of Popular Astronomy.

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## Phenomena of Jupiter's Satellites.

[Central Standard Time.]

The hours after Midnight are numbered 12h, 13h, 14h, etc.

Note.—In., denotes ingress; Eg., egress; Dis., disappearance; Re., reappearance; Ec., eclipse; Oc., denotes occultation; Tr., transit of the satellite; Sh., transit of the shadow.

| | h | m | |
|---|---|---|---|
| Jan. 1 | 4 | 36 | I Sh. In. |
| | 5 | 35 | II Sh. In. |
| | 5 | 54 | I Tr. Eg. |
| | 6 | 19 | II Tr. Eg. |
| | 6 | 49 | I Sh. Eg. |
| | 8 | 12 | II Sh. Eg. |
| 3 | 4 | 58 | III Ec. Re. |
| 5 | 13 | 50 | I Oc. Dis. |
| 6 | 11 | 03 | I Tr. In. |
| | 11 | 29 | II Oc. Dis. |
| | 12 | 02 | I Sh. In. |
| | 13 | 15 | I Tr. Eg. |
| | 13 | 19 | III Tr. In. |
| | 14 | 15 | I Sh. Eg. |
| | 15 | 7 | III Tr. Eg. |
| 7 | 8 | 18 | I Oc. Dis. |
| | 11 | 29 | I Ec. Re. |
| 8 | 5 | 30 | I Tr In. |
| | 6 | 09 | II Tr. In |
| | 6 | 31 | I Sh. In. |
| | 7 | 42 | I Tr. Eg. |
| | 8 | 14 | II Sh. In. |
| | 8 | 43 | II Tr. Eg. |
| | 8 | 44 | I Sh. Eg. |
| | 10 | 51 | II Sh. Eg. |
| 9 | 5 | 58 | I Ec. Re. |
| 10 | 4 | 46 | III Oc. Re. |
| | 5 | 18 | II Ec. Re. |
| | 7 | 16 | III Ec. Dis. |
| | 9 | 0 | III Ec. Re. |
| 13 | 12 | 51 | I Tr. In. |
| | 13 | 52 | II Oc. Dis. |
| | 13 | 58 | I Sh. In. |
| 14 | 10 | 07 | I Oc. Dis. |
| | 13 | 25 | I Ec. Re. |
| 15 | 7 | 19 | II Tr. In. |
| | 8 | 26 | I Sh. In. |
| | 8 | 35 | II Tr. In. |
| | 9 | 32 | I Tr. Eg. |
| | 10 | 39 | I Sh. Eg. |
| | 10 | 52 | II Sh. In. |

| | h | m | |
|---|---|---|---|
| Jan. 15 | 11 | 10 | II Tr. Eg. |
| | 13 | 30 | II Sh. Eg. |
| 16 | 7 | 54 | I Ec. Re. |
| 17 | 5 | 08 | I Sh. Eg. |
| | 6 | 34 | III Oc. Dis. |
| | 7 | 52 | II Ec. Re. |
| | 8 | 26 | III Oc. Re. |
| | 11 | 17 | III Ec. Dis. |
| | 13 | 03 | III Ec. Re. |
| 21 | 11 | 58 | I Oc. Dis. |
| 22 | 9 | 09 | I Tr. In. |
| | 10 | 21 | I Sh. In. |
| | 11 | 04 | II Tr. In. |
| | 11 | 22 | I Tr. Eg. |
| | 12 | 35 | I Sh. Eg. |
| | 13 | 31 | II Sh In. |
| | 13 | 39 | II Tr. Eg. |
| 23 | 6 | 26 | I Oc. Dis. |
| | 9 | 50 | I Ec. Re. |
| 24 | 4 | 50 | I Sh. In. |
| | 5 | 31 | II Oc. Dis. |
| | 5 | 50 | I Tr. Eg. |
| | 7 | 03 | I Sh. Eg. |
| | 10 | 16 | III Oc. Dis. |
| | 10 | 30 | II Ec. Re. |
| 24 | 12 | 12 | III Oc. Re. |
| 26 | 5 | 28 | II Sh. Eg. |
| 28 | 5 | 19 | III Sh. In. |
| | 6 | 20 | III Sh. Eg. |
| 29 | 11 | 01 | I Tr. In. |
| | 12 | 17 | I Sh. In. |
| | 13 | 14 | I Tr. Eg. |
| 30 | 8 | 18 | I Oc. Dis. |
| | 11 | 46 | I Ec. Re. |
| 31 | 5 | 29 | I Tr. In. |
| | 6 | 45 | I Sh. In. |
| | 7 | 42 | I Tr. Eg. |
| | 8 | 00 | II Oc. Dis. |
| | 8 | 59 | I Sh. Eg. |
| | 13 | 02 | II Ec. Re. |

## COMET AND ASTEROID NOTES.

Planet (554) [1905 PS] has been named Peraga, (569) [1905 QT] is called Misa by its discoverer Dr. J. Palisa.

**New Comet Schaer.**—A new bright comet was discovered by Schaer, at Geneva, Switzerland, on the night of November 17. It was then within four degrees of the north pole of the heavens, being a little over three degrees from Polaris and nearly on a line from Polaris to Capella. The discovery was announced to astronomers all over the world by the following cipher message from the Observatory at Kiel, Germany:

"Unman Schaer Geneva November dryness bodily acclivous zero bigboned luskishly abetes."

This message was cabled from Kiel to Harvard College Observatory and from Harvard was transmitted by telegram to the various observatories in the United States. The translation of the message is

"A bright comet was discovered by Schaer, at Geneva, Switzerland, November 17.322, Greenwich mean time, in right ascension $4^h\ 22^m\ 32^s$ and declination north 86° 00′. Daily motion in right ascension $-\ 3^h\ 56^m$; in declination south 1° 00′."

The comet is moving rapidly toward the south and, by the time this magazine reaches the reader, will probably be south of the equator. On November 21, it was in the southwestern part of the constellation Cassiopeia and the prolongation of its present course will carry it through the middle of Pegasus and Aquarius. As seen with the five-inch finder of the telescope at Goodsell Observatory the comet is quite conspicuous and it no doubt can be picked up easily with a three-inch telescope. It is nearly round, perhaps five or six minutes in diameter, with a strong central condensation. In the 16-inch telescope the appearance is much the same. The nucleus is bright but not star like.

The following positions of the comet are all that have come to hand:

| Greenwich Mean Time | R. A. h m s | Decl. ° ′ ″ | Observer | Place |
|---|---|---|---|---|
| Nov. 17.322 | 4 22 32 | + 86 00 | Schaer | Geneva. |
| 18.2549 | 0 58 19.5 | + 81 40 05 | Hartwig | Bamberg. |
| 18.6834 | 0 33 54.4 | + 77 17 26 | Aitken | Mt. Hamilton. |
| 19.8362 | 0 02 14.0 | + 67 23 38 | Morgan | Glasgow, Mo. |

The new comet Schaer was observed by Wilson at Northfield.

Nov. 21.5639 Gr. M. T. $\alpha = 23^h\ 45^m\ 41^s.34$; $\delta = +\ 52°\ 07'\ 03''.7$

The following are elements and ephemeris of Comet *b* 1905, by Herbert R. Morgan, Morrison Observatory, Glasgow, Missouri:

Elements

| | ° ′ |
|---|---|
| Ω = | 219 50 |
| *i* = | 145 32 |
| ω = | 120 6 |
| π = | 99 43 |

T = October 18.896 G. M. T. 1905

log *q* = 6.99973

Ephemeris

| G. M. T. | α h m | δ ° ′ |
|---|---|---|
| Nov. 21.5 | 23 48 | + 53 15 |
| 25.5 | 36 | 27 19 |
| 29.5 | 32 | 12 47 |
| 33.5 | 23 32 | + 4 34 |

**Numbering Recently Discovered Minor Planets.**

| Number | Provisional Designation | Discoverer | Date 1905 |
|---|---|---|---|
| 554 | 1905 PS | P. Götz | Jan. 8 |
| 555 | 1905 PT | M. Wolf | Jan. 14 |
| 556 | 1905 PW | P. Götz | Jan. 8 |
| 557 | 1905 PY | M. Wolf | Jan. 26 |
| 558 | 1905 QB | M. Wolf | Feb. 6 |
| 559 | 1905 QD | M. Wolf | March 8 |
| 560 | 1905 QF | M. Wolf | March 13 |
| 561 | 1905 QG | M. Wolf | March 26 |
| 562 | 1905 QH | M. Wolf | April 3 |
| 563 | 1905 QK | P Götz | April 6 |
| 564 | 1905 QM | P. Götz | May 9 |
| 565 | 1905 QN | M. Wolf | May 9 |
| 566 | 1905 QO | P. Götz | May 28 |
| 567 | 1905 QP | P. Götz | May 28 |
| 568 | 1905 QS | P. Götz | July 26 |
| 569 | 1905 QT | J. Palisa | July 27 |

**Preliminary Elements of Recently Discovered Minor Planets.**

| Planet | No. | $T$ 1905 | $M$ | | | $\Omega$ | | |
|---|---|---|---|---|---|---|---|---|
| | | | ° | ′ | ″ | ° | ′ | ″ |
| 1905 PS | (554) | Jan. 12.5 | 44 | 44 | 50.5 | 124 | 19 | 15.1 |
| 1905 PT | (555) | Jan. 14.5 | 2 | 59 | 42.0 | 350 | 52 | 13.1 |
| 1905 PW | (556) | Jan. 16.5 | 15 | 36 | 17.7 | 175 | 4 | 16.5 |
| 1905 PY | (557) | Jan. 14.5 | 1 | 42 | 52.4 | 190 | 1 | 10.1 |
| 1905 QB | (558) | Feb. 9.5 | 41 | 17 | 34.4 | 314 | 40 | 6.0 |
| 1905 QD | (559) | April 20.5 | 321 | 9 | 51.5 | 125 | 30 | 35.7 |
| 1905 QF | (560) | March 13.5 | 22 | 18 | 46.4 | 33 | 12 | 7.3 |
| 1905 QG | (561) | Marc1 30.5 | 67 | 22 | 32.6 | 302 | 12 | 37.9 |
| 1905 QH | (562) | April 8.5 | 241 | 39 | 15.7 | 257 | 20 | 51.8 |
| 1905 QK | (563) | May 30.5 | 153 | 53 | 28.2 | 333 | 32 | 9.6 |
| 1905 QM | (564) | May 9.5 | 329 | 14 | 30.6 | 211 | 29 | 1.6 |
| 1905 QN | (565) | May 9.5 | 69 | 45 | 0.0 | 290 | 15 | 49.5 |
| 1905 QO | (566) | June 1.5 | 232 | 36 | 44.7 | 303 | 22 | 2.8 |
| 1905 QP | (567) | June 3.5 | 34 | 48 | 12.4 | 149 | 56 | 49.2 |
| 1905 QS | (568) | Aug. 21.5 | 291 | 43 | 54.1 | 170 | 31 | 56.0 |
| 1935 QT | (569) | Sept. 5.5 | 280 | 29 | 19.6 | 137 | 37 | 20.8 |
| 1905 QU | (406) | Aug. 31.5 | 352 | 15 | 46 2 | 34 | 31 | 8.3 |

**Preliminary Elements of Recently Discovered Minor Planets.**—Continued.

| No. | ☊ | | | $i$ | | | $\phi$ | | | $\mu$ | log $a$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | ° | ′ | ″ | ° | ′ | ″ | ° | ′ | ″ | ″ | |
| (554) | 295 | 43 | 54.3 | 2 | 56 | 21.3 | 8 | 56 | 10.6 | 969.219 | 0.375723 |
| (555) | 130 | 53 | 27.6 | 2 | 38 | 46.4 | 8 | 50 | 39.9 | 624.247 | 0.503100 |
| (556) | 285 | 50 | 40.1 | 5 | 14 | 17.6 | 5 | 46 | 43.4 | 915.845 | 0.392123 |
| (557) | 293 | 21 | 1.7 | 2 | 31 | 8.5 | 5 | 35 | 58.3 | 926.968 | 0.388628 |
| (558) | 144 | 15 | 43.8 | 8 | 21 | 3.0 | 2 | 14 | 1.0 | 715.481 | 0.463606 |
| (559) | 112 | 23 | 20.2 | 9 | 18 | 15.0 | 3 | 45 | 2.0 | 794.666 | 0.433215 |
| (560) | 103 | 41 | 12.8 | 8 | 13 | 40.2 | 7 | 5 | 19.7 | 778.172 | 0.439287 |
| (561) | 160 | 30. | 7.0 | 1 | 30 | 51.5 | 8 | 42 | 31.0 | 624.357 | 0.503049 |
| (562) | 71 | 37 | 20.1 | 11 | 8 | 31.1 | 5 | 25 | 14.8 | 677.324 | 0.479473 |
| (563) | 84 | 51 | 35.6 | 10 | 20 | 46.4 | 13 | 56 | 47.2 | 792.084 | 0.434157 |
| (564) | 71 | 13 | 6.9 | 18 | 14 | 26.4 | 15 | 50 | 16.2 | 776.674 | 0.439845 |
| (565) | 225 | 49 | 48.3 | 10 | 53 | 59.5 | 7 | 18 | 40.0 | 931.272 | 0.387286 |
| (566) | 81 | 28 | 10.8 | 5 | 1 | 27.9 | 6 | 55 | 16 7 | 577.344 | 0.525714 |
| (567) | 59 | 6 | 21.0 | 8 | 59 | 5.6 | 4 | 55 | 30.7 | 641.903 | 0.495025 |
| (568) | 250 | 7 | 21.1 | 18 | 21 | 6.0 | 9 | 40 | 10.3 | 725.727 | 0.459489 |
| (569) | 303 | 2 | 30.5 | 1 | 17 | 8.5 | 10 | 12 | 17.8 | 822.367 | 0.423294 |
| (406) | 317 | 4 | 34.1 | 4 | 14 | 54.6 | 10 | 10 | 53.0 | 710.727 | 0.465535 |

## VARIABLE STARS.

### Variable Stars of Short Period not of the Algol Type.

The terms of maxima only are given; the times of minima may be obtained by subtracting the interval printed in parentheses under the name of the star.

**T Monocerotis**

| | d | h |
|---|---|---|
| | (7 | 22) |
| Jan. | 13 | 1 |

**W Geminorum**

| | d | h |
|---|---|---|
| | (2 | 15) |
| Jan. | 3 | 20 |
| | 11 | 14 |
| | 19 | 8 |
| | 27 | 1 |

**ζ Geminorum**

| | d | h |
|---|---|---|
| | (5 | 0) |
| Jan. | 9 | 6 |
| | 19 | 10 |
| | 29 | 14 |

**V Carinæ**

| | d | h |
|---|---|---|
| | (2 | 4) |
| Jan. | 5 | 2 |
| | 11 | 19 |
| | 18 | 11 |
| | 25 | 4 |
| | 31 | 21 |

**T Velorum**

| | d | h |
|---|---|---|
| | (1 | 9½) |
| Jan. | 1 | 12 |
| | 6 | 3 |
| | 10 | 18 |
| | 15 | 10 |
| | 20 | 1 |
| | 24 | 16 |
| | 29 | 8 |

**W Carinæ**

| | d | h |
|---|---|---|
| | (0 | 23) |
| Jan. | 4 | 20 |
| | 9 | 5 |
| | 13 | 14 |
| | 17 | 23 |
| | 22 | 8 |
| | 26 | 16 |
| | 31 | 1 |

**S Muscæ**

| | d | h |
|---|---|---|
| | (3 | 11) |
| Jan. | 10 | 8 |
| | 19 | 23 |
| | 29 | 15 |

**T Crucis**

| | d | h |
|---|---|---|
| | (2 | 1) |
| Jan. | 5 | 7 |
| | 12 | 0 |
| | 18 | 18 |
| | 25 | 12 |

**R Crucis**

| | d | h |
|---|---|---|
| | (1 | 9) |
| Jan. | 6 | 13 |
| | 12 | 9 |
| | 18 | 4 |
| | 24 | 0 |
| | 29 | 0 |

**S Crucis**

| | d | h |
|---|---|---|
| | (1 | 12) |
| Jan. | 1 | 10 |
| | 6 | 2 |
| | 10 | 19 |

**S Crucis**

| | d | h |
|---|---|---|
| Jan. | 15 | 11 |
| | 20 | 4 |
| | 24 | 21 |
| | 29 | 13 |

**W Virginis**

| | d | h |
|---|---|---|
| | (8 | 4) |
| Jan. | 5 | 0 |
| | 22 | 6 |

**V Centauri**

| | d | h |
|---|---|---|
| | (1 | 12) |
| Jan. | 1 | 2 |
| | 6 | 13 |
| | 12 | 2 |
| | 17 | 14 |
| | 23 | 2 |
| | 28 | 14 |

**R Triang. Austr.**

| | d | h |
|---|---|---|
| | (1 | 0) |
| Jan. | 3 | 16 |
| | 7 | 1 |
| | 10 | 11 |
| | 13 | 20 |
| | 17 | 5 |
| | 20 | 15 |
| | 24 | 0 |
| | 27 | 9 |
| | 30 | 19 |

**S Triang. Austr.**

| | d | h |
|---|---|---|
| | (2 | 2) |
| Jan. | 6 | 13 |
| | 12 | 20 |

**S Triang. Austr.**

| | d | h |
|---|---|---|
| Jan. | 19 | 4 |
| | 25 | 12 |
| | 31 | 20 |

**S Normæ**

| | d | h |
|---|---|---|
| | (4 | 9) |
| Jan. | 3 | 0 |
| | 12 | 18 |
| | 22 | 12 |

**R V Scorpii**

| | d | h |
|---|---|---|
| | (1 | 9) |
| Jan. | 3 | 12 |
| | 9 | 13 |
| | 15 | 15 |
| | 21 | 16 |
| | 27 | 18 |

**X Sagittarii**

| | d | h |
|---|---|---|
| | (2 | 21) |
| Jan. | 3 | 14 |
| | 10 | 15 |
| | 17 | 15 |
| | 24 | 15 |
| | 31 | 16 |

**Y Ophiuchi**

| | d | h |
|---|---|---|
| | (6 | 5) |
| Jan. | 9 | 9 |
| | 26 | 11 |

**W Sagittarii**

| | d | h |
|---|---|---|
| | (3 | 0) |
| Jan. | 7 | 10 |
| | 15 | 1 |
| | 22 | 15 |
| | 30 | 5 |

**Y Sagittarii**

| | d | h |
|---|---|---|
| | (2 | 2) |
| Jan. | 1 | 21 |
| | 7 | 16 |
| | 13 | 10 |
| | 19 | 5 |
| | 30 | 18 |

**U Sagittarii**

| | d | h |
|---|---|---|
| | (3 | 0) |
| Jan. | 3 | 21 |
| | 10 | 15 |
| | 17 | 8 |
| | 24 | 2 |
| | 30 | 20 |

**β Lyræ**

| | d | h |
|---|---|---|
| | (3 | 2) |
| | (3 | 7) |
| Jan. | 3 | 22 |
| | 10 | 16 |
| | 17 | 3 |
| | 23 | 14 |
| | 30 | 1 |

**κ Pavonis**

| | d | h |
|---|---|---|
| | (4 | 9) |
| Jan. | 9 | 12 |
| | 18 | 15 |
| | 27 | 17 |

**δ Cephei**

| | d | h |
|---|---|---|
| | (1 | 9) |
| Jan. | 1 | 19 |
| | 7 | 4 |
| | 12 | 12 |
| | 17 | 21 |
| | 23 | 6 |
| | 28 | 15 |

### Maxima of RZ Lyræ.

Period $0^d\ 12^h\ 16^m\ 15^s.0$

| | h |
|---|---|
| Jan. 1 | 11 |
| 2 | 12 |
| 3 | 12 |
| 4 | 13 |
| 5 | 13 |
| 6 | 14 |
| 7 | 14 |
| Jan. 8 | 15 |
| 9 | 15 |
| 10 | 16 |
| 11 | 16 |
| 12 | 17 |
| 13 | 17 |
| 14 | 18 |
| Jan. 15 | 18 |
| 16 | 19 |
| 17 | 20 |
| 18 | 20 |
| 19 | 21 |
| 20 | 21 |
| 21 | 22 |
| Jan. 22 | 22 |
| 23 | 23 |
| 24 | 23 |
| 26 | 0 |
| 27 | 0 |
| 28 | 1 |
| 29 | 1 |
| 30 | 2 |
| 31 | 2 |

## Approximate Magnitudes of Variable Stars on Nov. 10, 1905.

[Communicated by the Director of Harvard College Observatory, Cambridge, Mass.]

| Name. | R. A. 1900. h | m | Decl. 1900. ° | ′ | Magn. | Name. | R. A. 1900. h | m | Decl. 1900. ° | ′ | Magn. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| T Androm. | 0 | 17.2 | +26 | 26 | 8.5*d* | R Camelop. | 14 | 25.1 | +84 | 17 | 10 *i* |
| T Cassiop. | 0 | 17.8 | +55 | 14 | 12.3*d* | R Bootis | 14 | 32.8 | +27 | 10 | 12.5*d* |
| R Androm. | 0 | 18.8 | +38 | 1 | 13.5*d* | S Librae | 15 | 15.6 | −20 | 2 | *s* |
| S Ceti | 0 | 19.0 | − 9 | 53 | 13.0*d* | S Serpentis | 15 | 17.0 | +14 | 40 | 11.5*d* |
| S Cassiop. | 1 | 12.3 | +72 | 5 | *f* | S Coronae | 15 | 17.3 | +31 | 44 | 13 |
| R Piscium | 1 | 25.5 | + 2 | 22 | 12*d* | S Urs. Min. | 15 | 33.4 | +78 | 58 | 8.0 |
| U Persei | 1 | 52.9 | +54 | 20 | 9.3*d* | R Coronae | 15 | 44.4 | +28 | 28 | 6.0 |
| R Arietis | 2 | 10.4 | +24 | 36 | 11.5 *i* | V " | 15 | 45.9 | +39 | 52 | 12.0*d* |
| *o* Ceti | 2 | 14.3 | − 3 | 26 | 9.5 | R Serpentis | 15 | 46.1 | +15 | 26 | 11.5*d* |
| S Persei | 2 | 15.7 | +58 | 8 | 9.5 | R Herculis | 16 | 1.7 | +18 | 38 | 12.0*d* |
| R Ceti | 2 | 20.9 | − 0 | 38 | 14.3*d* | R Scorpii | 16 | 11.7 | −22 | 42 | *s* |
| U " | 2 | 28.9 | −13 | 35 | 12.2 *i* | S " | 16 | 11.7 | −22 | 39 | *s* |
| R Trianguli | 2 | 31.0 | +33 | 50 | 10.0 *i* | U Herculis | 16 | 21.4 | +19 | 7 | 11.7 |
| R Persei | 3 | 23.7 | +35 | 20 | 14 | W Herculis | 16 | 31.7 | +38 | 32 | 11.0*d* |
| R Tauri | 4 | 22.8 | + 9 | 56 | 8.5 *i* | R Draconis | 16 | 32.4 | +66 | 58 | 12.0*d* |
| S " | 4 | 23.7 | + 9 | 44 | 14 | S Herculis | 16 | 47.4 | +15 | 7 | 12.5 |
| R Aurigæ | 5 | 9.2 | +53 | 28 | 12.1*d* | R Ophiuchi | 17 | 2.0 | −15 | 58 | *s* |
| U Orionis | 5 | 49.9 | +20 | 10 | 11.1*d* | T Herculis | 18 | 5.3 | +31 | 0 | 11.5*d* |
| R Lyncis | 6 | 53.0 | +55 | 28 | 8.2 *i* | R Scuti | 18 | 42.2 | − 5 | 49 | 7.5*d* |
| R Gemin. | 7 | 1.3 | +22 | 52 | 8.7*d* | R Aquilae | 19 | 1.6 | + 8 | 5 | 12.3*d* |
| S Canis Min. | 7 | 27.3 | + 8 | 32 | 8.0 | R Sagittarii | 19 | 10.8 | −19 | 59 | 11.5*d* |
| R Cancri | 8 | 11.0 | +12 | 2 | 8.0 | S " | 19 | 13.6 | −19 | 12 | 10.5 *i* |
| V " | 8 | 16.0 | +17 | 36 | 9.0 | R Cygni | 19 | 14.1 | +49 | 58 | 14 |
| S Hydrae | 8 | 48.4 | + 3 | 27 | *f* | RT " | 19 | 40.8 | +48 | 32 | 7.5 *i* |
| T " | 8 | 50.8 | − 8 | 46 | *u* | X " | 19 | 46.7 | +32 | 40 | 8.8 *i* |
| R Leo. Min. | 9 | 39.6 | +34 | 58 | 7.0 | S " | 20 | 3.4 | +57 | 42 | 14.5*d* |
| R Leonis | 9 | 42.2 | +11 | 54 | 10.2 | RS " | 20 | 9.8 | +38 | 28 | 8.5*d* |
| R Urs. Maj. | 10 | 37.6 | +69 | 18 | 13.7*d* | R Delphini | 20 | 10.1 | + 8 | 47 | 12.2 *i* |
| R Comae Ber. | 11 | 59.1 | +19 | 20 | *u* | U Cygni | 20 | 16.5 | +47 | 35 | 7.5*d* |
| T Virginis | 12 | 9.5 | − 5 | 29 | *s* | V " | 20 | 38.1 | +47 | 47 | 13.5*d* |
| R Corvi | 12 | 14.4 | −18 | 42 | *s* | T Aquarii | 20 | 44.7 | − 5 | 31 | 8.1*d* |
| Y Virginis | 12 | 28.7 | − 3 | 52 | *s* | R Vulpec. | 20 | 59.9 | +23 | 26 | 8.4 *i* |
| T Urs. Maj. | 12 | 31.8 | +60 | 2 | 8.4 *i* | T Cephei | 21 | 8.2 | +68 | 5 | 10.5*d* |
| R Virginis | 12 | 33.4 | + 7 | 32 | *u* | S " | 21 | 36.5 | +78 | 10 | 10.5*d* |
| S Urs. Maj. | 12 | 39.6 | +61 | 38 | 10.6*d* | S Lacertae | 22 | 24.6 | +39 | 48 | 8.5*d* |
| U Virginis | 12 | 46.0 | + 6 | 6 | *u* | R " | 22 | 38.8 | +41 | 51 | 14.5 |
| V " | 13 | 22.6 | − 2 | 39 | *s* | S Aquarii | 22 | 51.8 | −20 | 53 | 11.5 *i* |
| R Hydrae | 13 | 24.2 | −22 | 46 | *s* | R Pegasi | 23 | 1.6 | +10 | 0 | 9.6*d* |
| S Virginis | 13 | 27.8 | − 6 | 41 | *s* | S " | 23 | 15.5 | + 8 | 22 | 7.8 *i* |
| R Can. Ven. | 13 | 44.6 | +40 | 2 | 12*d* | R Aquarii | 23 | 38.6 | +15 | 50 | 10.5 |
| S Bootis | 14 | 19.5 | +54 | 16 | 13.7 | R Cassiop. | 23 | 53.3 | +50 | 50 | 12.0*d* |

NOTE:—*f* denotes that the variable is probably fainter than the magnitude 13; *i*, that the light is increasing; *d*, that the light is decreasing; *s*, that it is near the Sun; and *u*, that its magnitude is unknown.

From observations made at the McCormick, Whiteside, Eadie and Harvard Observatories.

## Maxima of U Pegasi.

Period $0^d\ 4^h\ 29^m.8$

| | | h | | | h | | | h | | | h |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan. | 1 | 8 | Jan. | 9 | 5 | Jan. | 17 | 2 | Jan. | 24 | 23 |
| | 2 | 11 | | 10 | 8 | | 18 | 5 | | 26 | 2 |
| | 3 | 14 | | 11 | 11 | | 19 | 8 | | 27 | 5 |
| | 4 | 17 | | 12 | 14 | | 20 | 11 | | 28 | 8 |
| | 5 | 20 | | 13 | 17 | | 21 | 14 | | 29 | 11 |
| | 6 | 23 | | 14 | 20 | | 22 | 17 | | 30 | 14 |
| | 8 | 2 | | 15 | 23 | | 23 | 20 | | 31 | 17 |

## Minima of Variable Stars of the Algol Type.

[Given to the nearest hour in Greenwich Mean Time. To reduce to Central Standard time subtract 6 hours, or for Eastern time subtract 5 hours.]

### U Cephei.

| | d | h |
|---|---|---|
| Jan. | 2 | 16 |
| | 5 | 4 |
| | 7 | 16 |
| | 10 | 4 |
| | 12 | 16 |
| | 15 | 4 |
| | 17 | 15 |
| | 20 | 3 |
| | 22 | 15 |
| | 25 | 3 |
| | 27 | 15 |
| | 30 | 2 |

### Z Persei.

| | d | h |
|---|---|---|
| Jan. | 6 | 1 |
| | 9 | 3 |
| | 12 | 4 |
| | 15 | 5 |
| | 18 | 7 |
| | 21 | 8 |
| | 24 | 10 |
| | 27 | 11 |
| | 30 | 12 |

### Algol.

| | d | h |
|---|---|---|
| Jan. | 1 | 3 |
| | 4 | 0 |
| | 6 | 20 |
| | 9 | 17 |
| | 12 | 14 |
| | 15 | 11 |
| | 18 | 8 |
| | 21 | 5 |
| | 24 | 1 |
| | 26 | 22 |
| | 29 | 19 |

### RT Persei

| | d | h |
|---|---|---|
| Jan. | 1 | 16 |
| | 2 | 13 |
| | 3 | 9 |
| | 4 | 5 |
| | 5 | 2 |
| | 5 | 22 |
| | 6 | 19 |
| | 7 | 15 |
| | 8 | 11 |
| | 9 | 8 |
| | 11 | 1 |
| | 11 | 21 |
| | 12 | 17 |
| | 13 | 14 |
| | 14 | 10 |
| | 15 | 6 |
| | 16 | 3 |
| | 16 | 23 |
| | 17 | 20 |
| | 18 | 16 |
| | 19 | 12 |
| | 20 | 9 |

### RT Persie

| | d | h |
|---|---|---|
| Jan. | 21 | 5 |
| | 22 | 2 |
| | 22 | 22 |
| | 23 | 18 |
| | 24 | 15 |
| | 25 | 11 |
| | 26 | 7 |
| | 27 | 4 |
| | 28 | 0 |
| | 28 | 21 |
| | 29 | 17 |
| | 30 | 13 |
| | 30 | 10 |

### λ Tauri

| | d | h |
|---|---|---|
| Jan. | 2 | 21 |
| | 6 | 20 |
| | 10 | 19 |
| | 14 | 17 |
| | 18 | 16 |
| | 25 | 15 |
| | 26 | 14 |
| | 30 | 13 |

### R Canis Maj.

| | d | h |
|---|---|---|
| Jan. | 2 | 2 |
| | 3 | 5 |
| | 4 | 9 |
| | 5 | 12 |
| | 6 | 15 |
| | 7 | 18 |
| | 8 | 22 |
| | 10 | 1 |
| | 11 | 4 |
| | 12 | 7 |
| | 13 | 11 |
| | 14 | 14 |
| | 15 | 17 |
| | 16 | 20 |
| | 18 | 0 |
| | 19 | 3 |
| | 20 | 6 |
| | 21 | 9 |
| | 22 | 13 |
| | 23 | 16 |
| | 24 | 19 |
| | 25 | 23 |
| | 27 | 2 |
| | 28 | 5 |
| | 29 | 8 |
| | 30 | 12 |
| | 31 | 15 |

### Y Camelop.

| | d | h |
|---|---|---|
| Jan. | 1 | 3 |
| | 4 | 11 |
| | 7 | 18 |
| | 11 | 1 |
| | 14 | 9 |
| | 17 | 16 |

### Y Camelop.

| | d | h |
|---|---|---|
| Jan. | 20 | 23 |
| | 24 | 7 |
| | 27 | 14 |
| | 30 | 21 |

### RR Puppis

| | d | h |
|---|---|---|
| Jan. | 3 | 13 |
| | 9 | 23 |
| | 16 | 10 |
| | 22 | 20 |
| | 29 | 6 |

### V Puppis.

| | d | h |
|---|---|---|
| Jan. | 2 | 3 |
| | 3 | 13 |
| | 5 | 0 |
| | 6 | 11 |
| | 7 | 22 |
| | 9 | 9 |
| | 10 | 20 |
| | 12 | 7 |
| | 13 | 18 |
| | 15 | 5 |
| | 16 | 16 |
| | 18 | 3 |
| | 19 | 13 |
| | 21 | 0 |
| | 22 | 11 |
| | 23 | 22 |
| | 25 | 9 |
| | 26 | 20 |
| | 28 | 7 |
| | 29 | 18 |
| | 31 | 5 |

### S Cancri.

| | d | h |
|---|---|---|
| Jan. | 8 | 6 |
| | 17 | 18 |
| | 27 | 6 |

### S Antliæ.

| | d | h |
|---|---|---|
| Jan. | 1 | 22 |
| | 2 | 22 |
| | 3 | 21 |
| | 4 | 20 |
| | 5 | 20 |
| | 6 | 19 |
| | 7 | 18 |
| | 8 | 18 |
| | 9 | 17 |
| | 10 | 16 |
| | 11 | 16 |
| | 12 | 15 |
| | 13 | 14 |
| | 14 | 14 |
| | 15 | 13 |
| | 16 | 12 |
| | 17 | 12 |
| | 18 | 11 |
| | 19 | 10 |
| | 20 | 10 |

### S Antliæ.

| | d | h |
|---|---|---|
| Jan. | 21 | 9 |
| | 22 | 8 |
| | 23 | 8 |
| | 24 | 7 |
| | 25 | 6 |
| | 26 | 6 |
| | 27 | 5 |
| | 28 | 4 |
| | 29 | 4 |
| | 30 | 3 |
| | 31 | 2 |

### S Velorum.

| | d | h |
|---|---|---|
| Jan. | 5 | 14 |
| | 11 | 12 |
| | 17 | 11 |
| | 23 | 9 |
| | 29 | 8 |

### W Urs. Maj.

| | d | h |
|---|---|---|
| Jan. | 1-31 | 13[h] |

### RR Velorum

| | d | h |
|---|---|---|
| Jan. | 2 | 10 |
| | 4 | 7 |
| | 6 | 3 |
| | 8 | 0 |
| | 9 | 20 |
| | 11 | 17 |
| | 13 | 13 |
| | 15 | 10 |
| | 17 | 6 |
| | 19 | 3 |
| | 20 | 23 |
| | 22 | 20 |
| | 24 | 16 |
| | 26 | 13 |
| | 28 | 9 |
| | 30 | 6 |

### Z Draconis.

| | d | h |
|---|---|---|
| Jan. | 2 | 3 |
| | 3 | 12 |
| | 4 | 20 |
| | 6 | 5 |
| | 7 | 13 |
| | 8 | 22 |
| | 10 | 7 |
| | 11 | 15 |
| | 13 | 0 |
| | 14 | 8 |
| | 15 | 17 |
| | 17 | 1 |
| | 18 | 10 |
| | 19 | 19 |
| | 21 | 3 |
| | 22 | 12 |
| | 23 | 20 |
| | 25 | 5 |
| | 26 | 13 |
| | 27 | 22 |

### Z Draconis.

| | d | h |
|---|---|---|
| Jan. | 29 | 7 |
| | 30 | 15 |

### δ Libræ

| | d | h |
|---|---|---|
| Jan. | 2 | 4 |
| | 4 | 12 |
| | 6 | 20 |
| | 9 | 4 |
| | 11 | 12 |
| | 13 | 20 |
| | 16 | 3 |
| | 18 | 11 |
| | 20 | 19 |
| | 23 | 3 |
| | 25 | 11 |
| | 27 | 19 |
| | 30 | 3 |

### U Coronæ

| | d | h |
|---|---|---|
| Jan. | 3 | 0 |
| | 6 | 11 |
| | 9 | 22 |
| | 13 | 9 |
| | 16 | 19 |
| | 20 | 6 |
| | 23 | 17 |
| | 27 | 4 |
| | 30 | 15 |

### R Aræ

| | d | h |
|---|---|---|
| Jan. | 4 | 18 |
| | 9 | 4 |
| | 13 | 14 |
| | 18 | 0 |
| | 22 | 10 |
| | 26 | 21 |
| | 31 | 7 |

### U Ophiuchi.

| | d | h |
|---|---|---|
| Jan. | 1 | 9 |
| | 2 | 5 |
| | 3 | 1 |
| | 3 | 21 |
| | 4 | 18 |
| | 5 | 14 |
| | 6 | 10 |
| | 7 | 6 |
| | 8 | 2 |
| | 8 | 22 |
| | 9 | 18 |
| | 10 | 14 |
| | 11 | 11 |
| | 12 | 7 |
| | 13 | 3 |
| | 13 | 23 |
| | 14 | 19 |
| | 15 | 15 |
| | 16 | 11 |
| | 17 | 7 |
| | 18 | 4 |
| | 19 | 0 |

**Minima of Variable Stars of the Algol Type.**—Continued.

| U Ophiuchi. | | | U Ophiuchi. | | | Z Herculis. | | | Z Herculis. | | | RW Lyræ. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | d | h | | d | h | | d | h | | d | h | | d | h |
| Jan. | 19 | 20 | Jan. | 28 | 5 | Jan. | 9 | 18 | Jan. | 29 | 17 | Jan. | 23 | 12 |
| | 20 | 16 | | 29 | 1 | | 11 | 21 | | 31 | 20 | | 27 | 2 |
| | 21 | 12 | | 29 | 21 | | 13 | 18 | | | | | 30 | 17 |
| | 22 | 8 | | 30 | 18 | | 15 | 20 | RW Lyræ. | | | | | |
| | 23 | 4 | | 31 | 14 | | 17 | 17 | | 1 | 22 | UZ Cygni | | |
| | 24 | 0 | | | | | 19 | 20 | | 5 | 12 | Jan. | 3 | 23 |
| | 24 | 21 | Z Herculis. | | | | 21 | 17 | | 9 | 2 | Feb. | 4 | 7 |
| | 25 | 17 | Jan. | 3 | 21 | | 23 | 20 | | 12 | 17 | | | |
| | 26 | 13 | | 5 | 18 | | 25 | 17 | | 16 | 7 | | | |
| | 27 | 9 | | 7 | 21 | | 27 | 20 | | 19 | 22 | | | |

**Maxima of Y Lyræ.**

Period $0^d\ 12^h\ 03^m.9$

| | | h | | | h | | | h | | | h |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan. | 1-4 | 12 | Jan. | 5-11 | 13 | Jan. | 12-19 | 14 | Jan. | 20-27 | 15 |
| | | | | | | | | | | 28-31 | 16 |

**Maxima of UY Cygni.**

Period $0^d\ 13^h\ 27^m\ 27^s.59$

| | | h | | | h | | | h | | | h |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan. | 1 | 12 | Jan. | 9 | 8 | Jan. | 17 | 5 | Jan. | 25 | 1 |
| | 2 | 15 | | 10 | 11 | | 18 | 8 | | 26 | 4 |
| | 3 | 18 | | 11 | 14 | | 19 | 11 | | 27 | 7 |
| | 4 | 21 | | 12 | 17 | | 20 | 13 | | 28 | 10 |
| | 6 | 0 | | 13 | 20 | | 21 | 16 | | 29 | 13 |
| | 7 | 3 | | 14 | 23 | | 22 | 19 | | 30 | 16 |
| | 8 | 5 | | 16 | 2 | | 23 | 22 | | 31 | 19 |

**Two New Variables 67 and 106.1905 Ursae Majoris.**—In *A. N.* 451 Professor Ceraski calls attention to two new variable stars, discovered by Mme L. Ceraski upon the Moscow photographs. Their positions are as follows:

| | α 1855 | | | δ 1855 | | | α 1900.0 | | | δ 1900.0 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | h | m | s | ° | ′ | | h | m | s | ° | ′ | |
| 67.1905 | 12 | 32 | 19 | + 59 | 17.5 | | 12 | 34 | 23 | + 59 | 02.6 | |
| 106.1905 | 13 | 20 | 51 | + 63 | 08.7 | | 13 | 22 | 28 | + 62 | 54.6 | |

67.1905 is missing on seven plates taken September 7, September 8, October 2, 1904, April 26, April 30, May 1, and May 9, 1905. On plates taken August 5, and 6, 1905 its magnitude is 10.5, and on August 23 and 28, it had increased to 9.2. The variability of this star had already been discovered by Mrs. Fleming upon the Harvard photographs. 106.1905 was of the 10.5 magnitude on September 8, 1904 and 9.0 April 26, May 1, and May 9, 1905 but was invisible on photographs taken August 5, 6, 23 and 28, 1905.

**The Algol Variable 79.1905 Cephei (044880).**—The announcement was made in the Astronomische Nachrichten 169.111 by Professor Ceraski that the star whose position is R. A. $4^h\ 48^m\ 34^s$, December + 80° 5′.8 (1900) is a

variable of the Algol type. A careful watch has been kept of it by Mr. L. Campbell which showed that it was faint on the evenings of September 1, September 14, and October 21, 1905. A period of 12.5 days is thus indicated. From an examination by Mrs. Fleming of the photographs taken with the Cooke Anastigmat, it appears that the minima are nearly represented by the formula J. D 2410011.4 + 12.42 E. It may accordingly be expected to be faint on the dates given below: The average of this star is about 1.7 magn. and for four or five hours it remains at nearly constant minimum brightness. It will be noticed that the period $12^d.42$ is longer than that of any Algol star as yet discovered except UZ Cygni, 215543 which has a period of $31^d.304$. The next longest period is S Cancri 083819, period $9^d.485$.

| Epoch | J. D. 241 | G. M. T. d | h | m |
|---|---|---|---|---|
| 575 | 7152.90 | 1905 Nov. 2 | 21 | 36 |
| 576 | 7165.32 | 15 | 7 | 41 |
| 577 | 7177.74 | 27 | 17 | 45 |
| 578 | 7190.16 | Dec. 10 | 3 | 50 |
| 579 | 7202.58 | 22 | 13 | 55 |
| 580 | 7215.00 | 1906 Jan. 4 | 9 | 0 |

EDWARD C. PICKERING.

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Harvard College Observatory,
Cambridge, Mass.

## GENERAL NOTES.

**Thirty Year's Service as Assistant Secretary of Royal Astronomical Society.** At the completion of thirty years of service, as assistant secretary of the Royal Astronomical Society, Mr. W. H. Wesley was remembered by his many friends in the Society in a kind and substantial way. Professor H. H. Turner had before suggested and invited a friendly recognition of the long service. It was responded to by 168 subscribers who contributed a sum total of £155 9s 7d. It was further suggested that Mr. and Mrs. Wesley should take a holiday; and the report has it that they both loyally attended to that suggestion. They spent three happy weeks in Switzerland and Mr. Wesley calls it "the first holiday of their lives."

**Ephemeris for the Physical Observations of the Moon for 1906.** Observers interested in the telescopic study of the Moon will find A. C. D. Crommelin's table of data for such work in No. 9 of the *Monthly Notices*, of the Royal Astronomical Society pp. 872—882.

We see in the accompanying notes, that this ephemeris will not longer be published in the *Monthly Notices* but beginning with 1907 they are printed in the *Nautical Almanac*. An exception may be made in the case of the Saturn ephemeris which is not printed there, and so it will be continued in the *Monthly Notices*.

**Ralph Copeland.** With feelings of profound regret we have read the announcement of the death of Ralph Copeland, Astronomer Royal for Scotland and

Professor of Astronomy in the University of Edinburgh, which occurred, at his residence, on Friday morning, October 27, 1905. This sad intelligence was conveyed to us by post promptly, from the Royal Observatory at Edinburgh of which our lamented and scholarly friend has been so long its distinguished Director.

By the same foreign mail came a fitting and appreciative article about the life and work of Dr. Copeland that will appear in the next issue of this publication.

Many readers of POPULAR ASTRONOMY will feel the loss to astronomical circles of this eminent man who was so long and so well known in America.

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**A Catalogue of the Orbits of Visual Binary Stars.** R. G. Aitken of Lick Observatory has published a catalogue of 91 of the orbits of visual binary stars. The list contains the name of the star, its period, computer, authority, magnitude, right ascension and declination. About four pages of notes accompany the list of stars calling attention to some facts respecting particular stars that many aid in making the table as complete as possible in regard to present astronomical knowledge.

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**Naked Eye Sun-spot November 14, 1905.** W. W. Landis of Dickinson College, Carlisle Pa., writes that on Tuesday, November 14, Mr. Cobb, a member of the senior class of that Institution, saw with the naked eye, an interesting group of sun-spots. A good view of the Sun was secured by aid of the telescope and four groups of spots were seen. The principal spot in the largest group had an umbra nearly if not quite ten thousand miles in diameter. The whole number of distinct spots visible was about forty. Near the north east limb of the Sun two faint spots were seen (Trouvelot's veiled spots?). Beside the penumbra distinctly surrounding the principal spot, there were several lines of penumbral appearance dotted with small, round, and rather faint spots.

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**Different Methods of Determining Longitudes on Jupiter.** Several times during the last two years, articles have appeared in some of the leading astronomical journals in reference to the longitudes of certain markings on the surface of the planet Jupiter. The longitudes of these markings have been important, because such data were needed to determine the rotation time of the planet, as well as some other facts that might be learned from accurate observations in this regard.

Professor G. W. Hough of Dearborn Observatory, Evanston, Ill., and A. Stanley Williams, of Hove, England, have given special attention to the study of Jupiter's surface markings, for years past. Professor Hough has specialized so much and so well in this, that astronomers in America have come to regard his work as authority, almost without question.

On the other hand Mr. Williams of England, for some time past has questioned Professor Hough's method of work in determining his longitudes on Jupiter.

In his last paper in the Monthly Notices of the Royal Astronomical Society for June, this year, he speaks of four points, as the latest phases of the relative

efficiency of different methods of determining longitudes on Jupiter. They are:—1, The accidental errors of observation; 2, Systematic error; 3, Theoretical side of the question; and 4, Application to the planet Saturn.

The conclusions arrived at on each and all of these points do not indicate that these two astronomers are yet satisfied that their different methods give equally good and trustworthy results.

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**A Suggestion for the Next International Scheme.** Ernest Cooke suggested in the last number of the *Monthly Notices* of the Royal Astronomical Society, that the next scheme for international coöperation be to unite meridian observation work. He speaks of the present haphazard method of doing this kind of astronomical work that can not but lead to disappointing results, altogether disproportionate to the skill and labor expended. If the many, many star observations that have been made in the past, had been only properly coördinated we would now certainly have accurate star positions in abundance in every portion of the sky.

Mr. Cooke suggests the following plan:—

Let three catalogues be prepared as soon as possible, and astronomers be requested to confine their meridian or other exact work in the future, mainly to the stars in one or other of these catalogues.

A. Bright stars. This does not form part of the proposed scheme, but of course, the regular observation of the principal stars must be continued.

B. Fundamental stars for the general scheme. As a matter of detail I suggest that these be selected of about the sixth magnitude, and in every region of the sky.

C. Main catalogue, comprising, say, three stars to every square degree, and of course including the whole of B. This would make a total of 120,000 stars.

The plan and its details seem both feasible and desirable. In some such way good meridian work might be vastly increased in amount and with better results.

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**Solar Eclipse Observation.**—At the time of last contact of the solar eclipse of August 29-30, the sky was clear here, but the atmosphere unsteady. Mr. G. F. Paddock and I observed with the 26-inch equatorial, magnifying power 95; Mr. F. W. Reed and Mr. J. B. Smith with the 5-inch finder of the same, magnifying power 50. In each case the full aperture was employed and the image of the Sun projected on a screen, a sun-spot being used in focussing. The reduced observed local mean times of last contact are as follows:

| | | | |
|---|---|---|---|
| Ormond Stone | $19^h$ | $11^m$ | $25^s.9$ |
| G. F. Paddock | | | 28 .9 |
| F. W. Reed | | | 21 .9 |
| J. B. Smith | | | 20 .9 |
| American Ephemeris | | | 43 .3 |

September 19, Mr. Paddock observed the occultation of Aldebaran with the 26-inch equatorial at the following local mean times:

Immersion: $13^h\ 1^m\ 30.1^s$; Emersion: $13^h\ 55^m\ 18.7^s$.

ORMOND STONE.

Leander McCormick Observatory.
October 21, 1905.

**Total Solar Eclipse August 30, 1905, as seen at Vinaroz by A. L. Cortie.** We are favored by David E. Hadden of Alta, Ia., with an interesting letter and a photograph of the corona as seen by Father A. L. Cortie S. J. of England who was at Vinaroz, Spain, during the total eclipse of the Sun August 30, 1905. Portions of Father Cortie's letter descriptive of his work at the above named station are given below:

"I did not see your friend the Rev. Mr. Clegg. It is quite possible that he called when I was away in Spain, and so I missed him. Luckily I was favored by practically fine weather at my station at Vinaroz except for a few filmy clouds

THE CORONA, PHOTOGRAPHED AT VINAROZ, SPAIN.

that detached themselves from a big black bank that slowly rose in the S. W. I obtained six very good large scale (2.1 inches to solar diameter) photos of the corona with exposures varying from four to fifty seconds. The lens used was four inches aperture and nineteen feet four inches focal length fed with light by a coelostat eight inches in diameter. I enclose one of my prints, exposures fifteen seconds on an imperial ordinary backed plate as a specimen. The corona is decidedly of the maximum type.

With you I have remarked of the dearth of aurorae this maximum and the same remark has been made to me by Mr. Cordes. Also where are the big magnetic storms that ought to accompany such large spots as we have had lately.

I examined the one just gone with the spectroscope and photographed its spectrum. It was a filmy thing giving no depth to the general absorption. I agree with you that mirrors are the best for spectroscopic work, I get splendid spectra with a mirror six feet six inches focal length, seven inches aperture (Newtonian) replacing the flat reflector by a flat grating one inch aperture, and using the telescope the wrong way round so to speak."

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**Time at Royal Observatory, Cape of Good Hope.** In the last report of David Gill, Royal Astronomer at the Cape of Good Hope, for the year 1904, several things of general interest are noticed. One is the mounting of the new sidereal clock. This clock is provided with a nearly air-tight enclosure. The experimental trials that were made before satisfactory results could be reached furnish interesting reading for such as have to do with accurate time-keeping. When the variation of the daily rate of the clock was not greater than 0.03 of a second, its performance was regarded as quite satisfactory, though not deemed as accurate running as the new clock is capable of under still better conditions. Mr. Gill thinks these small variations show a dependence on the difference of temperature between the top and the bottom of the pendulum.

The clock is in an iron case surrounded by brass tubes through which water from an electrically heated boiler is circulated by means of a centrifugal pump worked by a small electro-motor. This work is done so well that the temperature of the water in the tubes is kept constant at 85° within one tenth of a degree. These tubes are covered with four fold felt with a wooden case outside. The loss of heat by radiation and convection is such that the interior of the clock case is two degrees below the temperature of the water, and the temperature of the surrounding air is about 65°. The difference of temperature between the upper and lower part of the case is variable to the extent of about one degree, depending on the difference between the external and internal temperature. A chamber eight feet square and thirteen feet high enclosing the clock case has recently been erected. The walls of this enclosure are of double one-inch flooring boards, nine inches apart, the intervening space being filled with dry sawdust. The whole is nearly air tight, as the boards next to the sawdust are lined with overlapping sheets of paraffined paper, and the door which is similarly stuffed, closes by pressure on India rubber tubes. It is believed by this means that a practically uniform temperature can be maintained day and night in all parts of the interior of the clock case. Another interesting feature in the time work at the Cape Observatory is the check on controlled clocks. "A clock in the Harbor Tower at the Cape Town Docks is normally controlled by electric currents automatically sent at each alternate second from the Observatory mean time clock. The coincidence of the beats of the two clocks can be verified either at the Observatory or the docks every minute, by means of galvanometers on the clock, there being a break make by the Observatory clock on the fiftieth second and by the Harbor clock at the sixtieth second, and therefore if the galvanometer of either clock shows breaks at the fiftieth and sixtieth second, it is certain that the two clocks are in coincidence."

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**Oscillations of the Solar Activity and the Climate.**—Dr. C. Easton has prepared two papers on the Oscillations of the solar activity and the climate which cover a period of 150 years in the first paper. He shows an interesting

parallelism between the solar activity and the variations of the magnetic elements of the Earth which are certain and he suspects that a similar agreement will be found between these changes of the Sun and some other terrestrial phenomena.

Some important conclusions are reached. This for one. "There exists oscillations of climate with a periodicity of 44½ years and multiples thereof, chiefly thus, that one period of 11.13 years contains less cold than the three preceding and the three following ones; that at intervals of 89 years there is one period with very little cold; that in two consecutive intervals of 89 years the last five or six periods of one of them are colder than the corresponding periods of the other interval. This oscillation of climate corresponds to an oscillation in the "solar activity", of a higher order than the well known eleven year period".

"On the whole the oscillations of the terrestrial temperature are accelerated relatively to the eleven year variation of solar activity in the colder part of the larger period, and retarded in the hotter part."

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**Professor Hale at a Meeting of the Royal Astronomical Society.** At a special meeting of the Royal Astronomical Society in October last Professor George E. Hale was present and made an address. A brief report of it appeared in the November number of the *Observatory*, from which we get the following short outline. He described the method of work by the spectroheliograph ( his favorite instrument) and showed some results obtained with it at the Yerkes Observatory, Williams Bay, Wis. He then gave a somewhat detailed description of the new Solar Observatory on Mount Wilson, California.

He said this new institution had its origin in a communication from Dr. S. P. Langley made to the Carnegie Institution in 1892 which recommended "the establishment of an observatory at a very great altitude to study the solar radiation, which it was thought might be variable during the sun-spot period. A committee was appointed to make a report on the detailed requirements of a complete Solar Observatory and to choose a location. As the result of tests of atmospheric conditions at various sites in southern California and Arizona Professor Hussey recommended Mount Wilson, near Pasadena and Los Angeles in southern California, as the place, and here, thanks to the liberality of the Carnegie Trustees the Observatory is being established."

Professor Hale then remarked that "in recent years telescopes have been growing, and spectroscopes have been growing but as yet there has been no attempt made to bring together the best instrument of each class. It is hoped to do this at Mount Wilson, and the principal instrument for this purpose is the Snow telescope, so named after Miss Helen Snow of Chicago who gave $11,000 in memory of her father, which was sufficient to complete the telescope and install it in a suitable house."

This instrument is a horizontal telescope, having a 24-inch mirror of long focus fed by a coelostat, and is to be used in conjunction with a spectroheliograph, spectroscope, thermopile, or other apparatus, for the study of sun-spots and other solar phenomena. The observatory also possesses a reflecting telescope with a five foot mirror mounted equatorially. A prominent feature of the Observatory is the elaborate and well equipped work-shop under the charge of Mr. Ritchey, which is placed at the foot of Mount Wilson in Pasadena, the difficulty of approach to the Observatory making this arrangement advisable.

Professor Hale showed photographs of the beautiful scenery around the

Observatory and described the conditions of existence there. The place is called "The Monastery" because the staff live in seclusion on the mountain, their families being left in Pasadena or its neighborhood. At the close the lecturer "was warmly applauded, and the after speakers agreed that the Society was fortunate in having this splendid Institution and its work described to them by the man who brought it into existence."

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**State Universities and Small Colleges.** The question that is now coming to the front in educational circles is new in form and very broad in meaning. It is so because it involves science in very fundamental ways. The great growth of State Universities during the last ten years and the small increase of the lesser colleges during the same period of time have led the friends of the former institutions to say quite loudly sometimes that the small college is passing away. It is soon to be a thing of the past.

The following is an extract from a most masterful address on the function of the State University delivered October 18, 1905, by Dr. E. J. James, at his own installation as President of the University of Illinois. He said But if I owed no personal debt or obligation to the Institutions (meaning non-state schools,) "if I had never for an hour enjoyed the benefit of instruction within their halls or from any one who came from them as teacher, still I should certainly be a blind, ignorant guide, indeed if I should by any remark of mine belittle these institutions or derogate in any way from the glory which properly belongs to them. We believers in state universities, whatever we may think of the future, must certainly acknowledge that we owe everything that we have been, and almost everything that we are, to these non-state institutions. If the history of American education were to be closed to-day, certainly the chapter devoted to the work of the state university would be very short and unimportant, indeed, as compared with that which should relate the history and services of the non-state institutions—Harvard, Yale, Brown, Columbia, Princeton, Leland Stanford, Dartmouth, Oberlin, Johns Hopkins and the hundred others—what a galaxy! and how proud we all are of them and their work! No thoughtful man, it seems to me, however much he may desire that our state university should wax, would like to see these non-state institutions wane, and I believe we should all feel that anything which would injure the efficiency or the work of any one of these institutions would be a calamity pure and simple.

In my own view, Northwestern, the Armour Institute of Technology, the University of Chicago, Milliken University, and the score and more of other non-state institutions engaged in the educational work of this state, are a vital, fundamental and essential part of the life of this community. I can not, of course, foresee how many of the numerous small colleges in this state are destined to survive. Some of them, perhaps, may disappear. Others, I believe, will be newly founded. All of them, and more too, will be needed when the population of this state shall be ten millions, as it will be before many years. But even for the present I can not help feeling that any means by which such institutions as Lake Forest, Knox College and the Wesleyan and McKendree and Illinois and Shurtleff and St. Ignatius and a dozen others can be enabled to do their work in a thorough and efficient manner, will be a cause for congratulation to every lover of education. We are all part of the same enterprise, engaged in working out the educational problems of this great commonwealth, and that enterprise is going to be the greater and the more glorious in proportion as each

of us is enabled to do fully and faithfully his part and portion in the work.

This long quotation is given because it is the truth, and it needs to be maintained boldly at any cost. Where are mathematics and astronomy most effectively fostered? Are these branches most generally taught at single points in the individual states by great universities? What are the 500 colleges of this nation doing to-day for a strong foundation in science generally? The thoughtful person can easily answer these questions without more comment.

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## Dr. EDMOND HALLEY.

As there seems now to be good reason to hope that an English astronomer, well known in America, will see the way to compile a complete Life of Dr. Halley, a key to sources of material may be of some advantage. Therefore, the short list following is submitted:—

**Clerke, Agnes M.** EDMUND HALLEY (*In* Dictionary of National Biography, Vol. 24, pages 104-109, New York, 1890.) [The best sketch of Halley extant; accompanied by many references to authorities and an excellent bibliography.]

**McPike, Eugene Fairfield.** [*Notes on*] DR. EDMOND HALLEY. (*In Notes and queries*, London, Ninth Series, Vol. X (1902), pages 361-362; Vol. XI (1903), pages 85-86, 205-206, 366, 463-464; Vol. XII (1903), pages 125-126, 185, 266-267, 464-465; Tenth Series, Vol 2 (1904), page 224.) [A bibliography with notes.]

——NOTES ON DR. EDMOND HALLEY. [A copy in the British museum, London; press-mark 10882 K 25. A miscellaneous collection of periodicals, pamphlets and documents.]

——HALLEY'S COMET: Its past history and 1910 return: a short bibliography with notes. 6 pp. (*In* Smithsonian Miscellaneous Collections, quarterly issue, Vol. 3, part 1, No. 1580 Washington, 1905.)

—*Same*, also issued separately. [*See* Addenda in *Popular Astronomy*, Vol 13, No. 8, October, 1905, page 471]

——HALLEY'S COMET AND ITS DISCOVERER (*In* the *Observatory*, Vol. 28, No. 358, June 1905, pages 256-257)

—Captain Edmond Halley's letters. (*In* the *Observatory*, Vol. 28, No. 360, August, 1905, pages 321-322.)

——INVENTORY OF THE RIGAUD PAPERS IN THE BODLEIAN LIBRARY, Oxford England. (*In* Smithsonian Miscellaneous Collections, quarterly issue, Vol. 3, part 2, pages 229-231.) [A list compiled by Mr. Ralph J. Beevor, M. A., London, England.]

—*Same*, also issued separately, as No. 1594, published September 8, 1905; "Smithsonian notes."

**McPike, Eugene Fairfield,** *and others.* Halley Family. *In Scottish notes and queries*, Aberdeen, second series, Vol. 6, (1904-5): pages 93, 112, 139, 151,159;—*Same*, Vol. 7 (1905-6): pages 36, 78, 79.) [A series of reference lists with notes principally genealogical.]

**Rudolph, Alexander J.** Material for a bibliography of Dr. Edmond Halley (1656-1742) by Alexander J. Rudolph, Assistant Librarian of the Newberry Library, Chicago, with some notes and addenda by Eugene Fairfield McPike (*In*

*Bulletin of Bibliography* Vol. 4, No. 4, July—1905, pages 53-57.)—*Same*, also issued separately, Boston: Boston Book Co., 1905.

**Tafel L. R.** *A. M., Ph. D. Editor*, DOCUMENTS concerning Swedenborg, London, 1890, 3 Volumes. (*See* biographical notice of Halley, 1:665; Halley mentioned, 1: 210, 227, 300; Halley admits correctness of Swedenborg's method of finding the longitude, 1: 222; Halley's magnetic chart, 1: 577-578.)

EUGENE F. MCPIKE.

Chicago, Nov, 14, 1905.

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**Good Books on Astronomy** for amateurs and for those who wish to know of the recent progress of Astronomy put in plain and untechnical language. So many queries are made for this kind of reading that we will mention here a few of them in the hope of meeting the wants of many others of whom we do not have knowledge.

A recent book of 280 pages by E. W. Maunder titled "Astronomy without a Telescope" can be obtained through any leading book dealer. It shows well what kind of work in astronomy may be done by the aid of any common astronomical instrument, by the aid of the eye alone. It shows how to train the hand and the eye in the observation of meteors, the Milky Way, Zodiacal light, Auroræ, work in connection with bright comets, besides a great deal of other useful information for popular readers.

"How to Know the Starry Heavens" by Edward Irving and published by Frederick A. Stokes and Company, New York, is a good book of 313 pages, fully and well illustrated. This book gives several of the simple problems of astronomy and shows how important results have been found, which are fundamental to the science. The studies of the Sun, Moon and the planet Mars are helpful and interesting.

"The Earth's Beginning" by Sir Robert S. Ball is a stirring book in popular language. It contains 384 pages and is published by D. Appleton and Company, 1903. The book opens with the nebular theory, then states the problem, and considers the old theory of "fire mist", dealing with the nebulæ, apparent and real, and shown by the aid of the modern spectroscope. It considers the heat of the Sun and how it is maintained with some glimpses into the history of the great solar orb. The Earth's beginning is then directly studied, and the evidences of earthquakes and volcanoes considered quite fully. The spiral and planetary nebulae and the evolution of the solar system contribute largely to the needed argument while the unity of material in the heavens and the Earth reinforce it very largely. The points of concord are set out distinctly and well, and then the objections to the nebular theory are enumerated. The beginning of the nebulæ the end of the Sun and the meaning of new stars finish the book.

"Astronomical Discovery" by H. H. Turner, and published by Edward Arnold of London is a piece of history for popular readers in astronomical subjects that is one of the most entertaining books that appeared in 1904. The author is a profound scholar, an easy writer and a recognized authority abroad and in America. The matter presented in this book is a real contribution to popular astronomy and easily accessible to any wishing the information conveyed.

The book entitled *Modern Astronomy* by the same author and published by E. P. Dutton & Co., New York, 1900 is also a very worthy piece of work.

**Graphical Calculus.**—Frederico Oom, of the Royal Observatory of Lisbon has recently published a paper on the methods of Graphical Calculus. It is fully illustrated and applied to some problems in astronomy.

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**Advanced Algebra by Dr. Hawkes.** Messrs. Ginn & Company are publishing some book, on the different branches of mathematics and its applications that are especially strong and up-to-date in method and quality. In the classes at Carleton College Granville's Differential and Integral Calculus has been in use during the first Semester for 1905-6 with most satisfactory results. That text, as we have before said, is the best example of a real thorough, systematic and naturally graded book for the beginner that we know of, both in development of principle and also in the choice and grading of ample exercise work.

Professor Herbert E. Hawkes of the department of mathematics, Yale University has also published an Advanced Algebra in this new series of mathematics from the presses of Ginn & Company. This book is adapted to use in the secondary schools and in College work where the shorter courses in Algebra can only be pursued. The first fourteen chapters deal with the fundamental operations, factoring, fractions, equations, ratio and proportion, irrational numbers and radicals, theory and indices, quadratic equations, graphical representation, quadratics with two variables, mathematical induction, binomial theorem, arithmetical progression and geometrical progression. This part of the book covers 140 pages.

The remainder is devoted to advanced algebra and considers respectively, permutations and combinations, complex numbers, theory of equations (quite fully) determinants, partial fractions, logarithms, continued fractions, inequalities, variation, probability and scales of notation.

The first part of this book is thorough, systematic and exact in defining and using the equation. The advanced part makes prominent the theory of equations and determinants. It also has a chapter on scales of notation. The feature of the graph the study of roots and to show the meaning geometrically of the intersection of simultaneous equations is a most excellent one. It can but add new meaning and new interest to the student who is doing this kind of work for the first time.

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**Finite and Infinite** is the title of a new book by Thomas Curran Ryan of the Wisconsin Bar, and published by J. B. Lippincott Company of Philadelphia.

The author has chosen a theme that will certainly interest many readers. He has treated it in plain language, in strong argument and in such definite phrase that no one can doubt his fairness though his conclusions are new and bold in his chosen lines of thinking.

The first part of the book is given up to *Actus Dei*. It is a sketch of evolution mingling the infinite and finite in a process of evolution that marks destiny at every slip; or conversely, if you please; for the author says: "Destiny is evolution; evolution is trend; and trend is infinite. Destiny comprehends an infinite number of finite conditions; it is the new ever replacing the old.....Hence it is that all great philosophers have given to the world their ideas of God, or of something they choose to put in His place. Then the author devotes 150 pages to a philosophical study of what he terms *Actus Dei*, beginning with truth and knowledge, he considers the absolute persistence of truth, the theoretical and the possi

ble, the constancy of phenomena and the finite and the infinite. Several other features of the discussion in this part of the book appear which need not be noticed here, but which are equally interesting and helpful to the reader as he follows out the author's plan in detailed argument.

The second part of the book presents the topic: *The Finite Universe*, and is the more important part for our present notice. This part begins with the question. What is the sky? The author's views on this subject were written out in an article and sent to POPULAR ASTRONOMY in 1894, but they were not published then, in full, because we did not think his views were in accord with good astronomy. In this decision we had the concurrence of two of the best physicists of the United States of which we then knew. We did, however, make a brief extract of the author's views of what the sky is, and gave some reasons why it was not thought best to publish the article as a whole. In this part of the book the whole matter is rehearsed in a courteous and very fair way and then the author proceeds to give his ideas of what the sky is, as he had done formerly, but now more fully, after further study. He quotes Herschel, Tyndall, Wallace and Spring, as agreeing that the blue color of the sky is produced by matter of some sort. He argues that the components of the color of the sky are matter and light, but he wants to know where the matter is located and from what source does the light come to produce this everlasting blue arch of heavens. Is it from our Sun? Or is it from the myriads of stars in the depths of space that shine there perpetually and gloriously as our Sun shines in the solar system. Here begins the author's argument to lay the foundation for his theory of the blue color of the sky. He considers Herschel's theory and Tyndall's laboratory experiment in which the scientist thought he was able to make a better piece of blue sky than was ever beheld in the heavens above. He speaks of the impregnable wall of the Sidereal city indicating that the blue sky may be found to exert beyond and outside of the starry Universe. Spring's criticism of Tyndall's experiment and the oxygen theory of the color of sky really supports the author's theory, as he thinks, when these facts and phenomena are fully and carefully considered. There is much valuable information in this part of the book, which we have not space here and now to consider. It deserves a fuller notice which we hope to give it at another time. We will reserve our views regarding some of the conclusions reached by the author until we can support them by fuller statements than we now have opportunity to give.

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**Change of Address:**—The postoffice address of Herman S. Davis, will hereafter, until further notice, be Dover, Delaware, instead of International Latitude Observatory, Gaithersburg, Maryland. All books and articles sent to be reviewed for the Astronomischer Jahresbericht, as well as all personal correspondence and papers, should be sent to Dover, Delaware.

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**The Beauty of the Fall Evening Skies.** Persons but a little interested in the look at the sky on any clear night at this time of the year must wonder at and admire the handiwork that they observe in early evening hours. We have often thought that the region of the sky in the vicinity of *Taurus* and *Orion*, at this time of the year, was the most beautiful and the most wonderful starry picture imaginable. The contrast in outline of the brighter parts of the

two great constellations adds greatly to the impressiveness of the picture. The bright stars in *Orion* given in color and figure present a view and charm that is supremely grand. As one now looks at the *Pleiades* and the *Hyades* with the resplendent Jupiter in the midst, one feels instinctively the touch of awe and unwonted sublimity.

If the observer will stop to think a little, and try to get the full meaning of what he sees, he can but be astonished and overwhelmed with the great thoughts that crowd upon him. This region is rich in result from modern study with modern astronomical instruments.

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**Important Articles in Recent Publications.** We give below a few of the titles of important articles on astronomical themes that have been noticed during the last month.

*Cosmical Evolution* by Professor G. H. Darwin, address at the meeting of the British Association in South Africa, 1905—*Observatory* for November.

*A Possible Celestial Catastrophe*, by J. E. Gore, the leading article in November *Knowledge*. The destruction of the world by fire.

*The Total Eclipse of Sun August 30 1905.* Two articles in *Knowledge*, last number.

*Researches of W. Schwarzchild on the Determination of the Photographic Magnitudes of the Stars* in *Bulletin Astronomique* for November. An extended study of this important theme.

*The Total Eclipse of the Sun August 30, 1905* in the *Bulletin* of the Astronomical Society of France by G. Penso; fully illustrated and particular in description. It is in French in last number.

*On the Evolution of the Solar System*, by F. R. Moulton. Astrophysical Journal for October. Illustrated and largely popular.

*Integrals of Planetary Motion Suitable for an Indefinite Length of Time*, by G. W. Hill *Astronomical Journal* for October 9. Largely mathematical with extended tabular results. A strong paper.

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**Errata.** Under middle chart, page 517 for *W* Delphini read *Y* Delphini.
Date for observed magnitudes page 519 should be October 10, 1905.

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## PUBLISHER'S NOTICES.

**Contributors** are asked to prepare copy carefully, and write *all proper names very plainly*. If other language than the English is used to any considerable extent it should be type-written. Manuscript to be returned should be accompanied by postage for that purpose.

**All Drawings** for publication should be done in India ink, twice the size that the cut will be on the printed page. The lines, figures and letters should be made even, very smooth and uniformly black in every part of the copy, in order to secure the best reproductions possible by the modern quick processes of en-

graving now most generally used.

**Proofs** will generally be sent to authors living in the United States, if copy is furnished before the first of the month preceding that of publication. We greatly prefer that authors should read their own proofs, and we will faithfully see that all corrections are made in the final proofs.

**Renewals.**—Notices of expiration of subscription are sent directly after the last number of this publication for which payment has been made. It is especially requested that subscribers will send renewal, or order for renewal, promptly as this publication will not be continued beyond the time for which it has been ordered.

**Astronomical News.**—It is very much desired on the part of the management, that brief news paragraphs of astronomical work in all the leading observatories of the United States be furnished to this publication, as regularly and as often as possible.

The work of amateur astronomers, and the mention of "personals" concerning prominent astronomers will be welcome at any time.

The building and equipping of new observatories, the manufacture, sale or purchase of new astronomical instruments, with special reference to improvements and new designs, and the results of new methods of work in popular language, will be deemed very important matter and will receive prompt attention. It is greatly desired that all persons interested bear us in mind and promptly respond to these requests.

**Messrs. Wm. Wesley & Son,** 28 Essex Street, Strand, London, England, are our sole European agents.

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